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SANTA CLARA VALLEY WATER DISTRICT

WATER NEEDS STUDY

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JUNE 1993

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EXECUTIVE SUMMARY

This report presents the update of the Santa Clara Valley Water District's long-term water needs projections for water supply planning. Good future water supply planning requires accurate forecasts of future needs. These projections of future water needs will be a basis for assessing the ability of the District to fulfill its water utility mission, to provide a supply of water, adequate as to both quantity and quality, needed to meet the desired quality of life in the community. The process of evaluating water needs is ongoing and evolutionary. The knowledge gained in making these projections helps identify areas for further attention. These projections represent a milestone in this process. This report also contains many suggestions for additional study and improvement.

RESULTS

The overall water needs projections of this study are similar to the previous District demand projection. However, the individual components of demand within separate types of water use differs from previous projections. Municipal and industrial (M&I) water use is estimated to be a larger proportion of water use than previously estimated. The addition of a range of water use depending upon weather conditions further increases the M&I component in critically dry years. Within this M&I water use, the percent of residential use is expected to decrease in the future, partially because changes in plumbing codes now mandate lower flow bathroom fixtures in homes. Agricultural water use is projected to be less than previous estimates. The combined total amount of water use projected for the year 2020 is estimated to be 539,000 acre-feet for hot dry weather conditions. The water needs projections for M&I, residential, agricultural, and unaccounted are shown in Tables ES-1 and ES-2. The projected total County water use for normal, dry, and wet years is plotted in Figure ES-1.

METHODS

These conclusions were drawn from extensive analysis of historic water use in the County and future projections of demographic data. Water use was forecast with residential equations taken from the U.S. Corps of Engineers IWR-MAIN forecasting system that were then calibrated for this County and with coefficients developed for the County's commercial and manufacturing, unaccounted, and agricultural water use. The calibrated equations were verified within 1 percent for north county total water use for 1980-87.

RECOMMENDATIONS

The water demand projections should be updated periodically to evaluate changes in water use characteristics and to update as additional demographic information becomes available. This is not expected to change the 2020 water demand significantly as year 2020 is approaching full development for the County. However, updates should be done to ensure the best future estimates of water needs are made.

The District and water retailers should begin working together to collect water use data by several customer classes. The present systems do not identify all residential, commercial and manufacturing use separately. This information is necessary before further meaningful improvements can be made in water demand forecasting methods. This data will also be useful in assessing water use and conservation patterns after the current drought situation returns to normal.

Water use in south county should be studied further after more metered data is collected. The present drought complicates data evaluation and recorded data is not sufficient to get good verification of the predictive equations at this time. Also, there is some pressure for significant changes in land use policies in south county which could have ramifications for projected water use.

TABLE ES-1
Water Need Predictions for Average Weather Conditions

	Year	Predicted Water Need (in AF)					
		Residential	C & I	Unaccounted	Conservation	Agriculture	Total
North County	1990	181,408	127,787	25,663	2,566	6,431	338,724
	2000	202,401	149,934	29,244	12,283	5,689	374,985
	2010	214,403	167,267	31,679	19,245	4,316	398,419
	2020	222,363	184,145	33,740	24,556	2,989	418,681
South County	1990	11,236	4,689	1,322	131	60,813	77,929
	2000	16,754	10,382	2,252	1,153	54,480	82,716
	2010	26,074	14,749	3,388	2,428	48,146	89,930
	2020	34,194	19,136	4,426	3,495	41,810	96,072
Total County	1990	192,645	132,477	26,985	2,697	67,244	416,653
	2000	219,155	160,317	31,496	13,436	60,169	457,701
	2010	240,477	182,016	35,067	21,673	52,462	488,349
	2020	256,557	203,281	38,167	28,050	44,799	514,753*

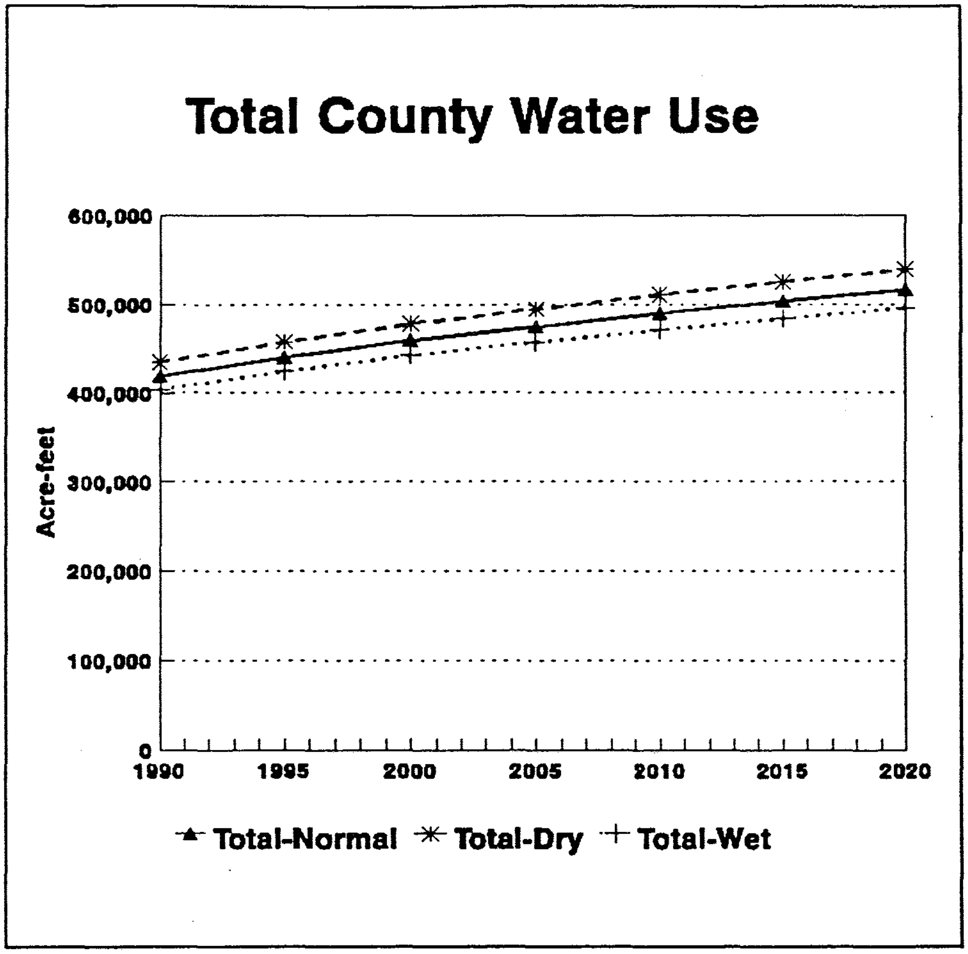
* Add an additional 1,000 acre-feet for groundwater remediation

TABLE ES-2
Water Need Predictions for Dry Weather Conditions

	Year	Predicted Water Need (in AF)					
		Residential	C & I	Unaccounted	Conservation	Agriculture	Total
North County	1990	194,408	127,787	26,742	2,566	6,431	352,803
	2000	216,870	149,934	30,445	12,283	5,689	390,655
	2010	229,725	167,267	32,950	19,245	4,316	415,013
	2020	238,279	184,145	35,061	24,556	2,989	435,919
South County	1990	12,765	4,689	1,449	131	60,813	79,585
	2000	18,924	10,382	2,432	1,153	54,480	85,066
	2010	29,643	14,749	3,685	2,428	48,146	93,795
	2020	39,032	19,136	4,828	3,495	41,810	101,311
Total County	1990	207,174	132,477	28,191	2,697	67,244	432,388
	2000	235,794	160,317	32,877	13,436	60,169	475,721
	2010	259,368	182,016	36,635	21,673	52,462	508,808
	2020	277,311	203,281	39,889	28,050	44,799	537,230*

* Add an additional 1,000 acre-feet for groundwater remediation

FIGURE ES-1


Total County Water Use
600,000
500,000
400,000
300,000
200,000
100,000
0
Acre-feet
1990
1995
2000
2005
2010
2015
2020
Total-Normal
Total-Dry
Total-Wet

CHAPTER 1. INTRODUCTION

I. PURPOSE AND SCOPE OF TASK

Projecting water needs is integral to water supply planning. Estimates of future water requirements are the basis of studies of alternatives to determine necessary facilities and programs to meet supplemental water needs. Knowledge of what generates the need for water assists in formulating appropriate programs to accommodate those needs.

Making projections consists of two parts; (1) studying water use and then (2) applying the knowledge gained to forecast the future. The District has recorded and studied water use for many years. This helps to define relationships for the many different components which determine water use. Alternate forecasts are investigated to judge a range of possibilities. Then a most likely projection is made.

A. Future Planning Horizon

Estimates of water use need to be made for a long-term planning horizon because water supply facilities require considerable lead time to complete and are generally planned to serve needs over a facility's life. Demand estimates are needed early to plan for future possibilities to ensure that facilities are available when they are needed. Year 2020 is the time when Santa Clara County is approaching full development. This 30-year period also provides the District with an adequate planning horizon.

B. Alternate Projections and Sensitivity Analysis

Actual water requirements are highly variable based on interaction of many different factors and future projections. These interactions and future estimates cannot be known with absolute certainty. Because water use projections rely on estimates, they also require evaluation of the range of future uncertainties. A sensitivity analysis and several alternate estimates provide information on ranges of projections.

C. Water Conservation

The present demand study evaluates the County's basic water needs. In the District's water supply planning, water conservation (also known as demand-side management) is primarily addressed in alternatives toward meeting this need. Conservation measures already in effect, such as changes in plumbing codes, which will reduce future water use independent of any future District programs, are included in the projections reported in this study.

II. PREVIOUS STUDIES

A. *1975 Master Plan* Projections

The District's ***1975 Master Plan*** projections have predicted very well over the years since they were made. The total results from the current study are very similar to the District's water use projections made over 20 years ago.

The ***1975 Master Plan*** projections used four variables for projecting water use. Population and density were used to estimate household use. The predicted 1990 population is within 2 percent (26,000 people lower than the census results). The population versus density relationship for water use was developed with recorded local data. Contrary to the previous trend, it assumed that per capita use would not increase with timc. This leveling off of per capita water use has since been confirmed for this County. This is consistent with Statewide trends. Employment and agricultural acreage were used to estimate commercial/industrial and agricultural use respectively. Coefficients were estimated using recorded water use. A higher crop factor was used in the southern portion of the County because it was assumed that crop patterns would change to crops having higher water requirements. A complete explanation of the analysis of water demands can be found in the ***1975 Master Plan*** text and appendix.

These projections include three assumptions of change in water use from the early 1970's water use patterns studied resulting from conservation efforts. First, per capita residential water use would not increase. This accounts for an estimated 35,000 AF saved per year by 2020. Second, outdoor water use was assumed to decrease 11,000 AF in the year 2020 from voluntary use of low water use landscaping. Third, implementation of the pump tax in Zone W-5 would result in a 20,000 AF reduction in water use by year 2020. A comparison of the resulting water use projections with recorded use indicates that these assumptions are being realized.

B. 1979 Draft Projections

In 1979, the District again evaluated future water requirements. This study used land use based methods to evaluate potential ultimate requirements. Per acre coefficients were developed for 17 categories of land use. Working with the County Planning Office, ultimate zoning was determined for every parcel of land. The development of the methodology is described in detail in "***Methodology for Projecting Water Needs***" SCVWD, 1979. The resulting projections are reported in the 1981 ***Draft Appendix A, Water Needs***. A comparison of the different water use coefficients developed in this 1979 study for different land uses is included in this current report. This provides information about how various future zoning changes could impact water needs.

III. UPDATE OF PROJECTIONS OVERVIEW

This study updates the water demand projections to utilize current information about demographics and water use patterns. Projections for jobs and households are used from the regional planning agency, Association of Bay Area Governments (ABAG) with review by local planning agencies incorporated. Residential equations from the Corps of Engineers demand forecasting model, IWR-MAIN, are calibrated specifically for this County. A nonresidential municipal and industrial per employee coefficient is developed from mid-1980s water use records. Agricultural demands are being estimated with the aid of metered water use records, aerial photography and the California Department of Water Resources interpretive maps. Alternate projections are studied and presented as a range of potential futures to evaluate in establishing planning objectives and scenarios.

CHAPTER 2. METHODOLOGY

Selection and development of the methods used to predict water demand is a fundamental part of every study. It is highly dependent on data availability and on relative importance of potential variables for future water demand projection. This chapter discusses the adoption of a projection method for this study.

I. TYPES OF APPROACHES

The first step taken in this development of future water demand projections was a review of forecasting methods currently in use and their requirements, advantages and limitations. Methods considered included time trend extrapolation, per capita analysis, unit use coefficient methods such as the District's previous land use based projection methodology, and multi-variate analysis such as District's previous ***1975 Master Plan*** methodology, and IWR-MAIN. Table 2-1 summarizes this review, listing the major factors involved in the selection of projection methods.

TABLE 2-1
Comparison of Forecasting Methods

Method	Data Required	Data Sources	Advantages	Limitations
Time Trend	●Water Use	●District Records: 24 years in W-2, 4 years in W-5	●Easy	●Based solely on math and past use without analysis of factors influencing use ●W-5 data is sparse
Per Capita	●Population ●Water Use	●ABAG ●District	●Easy ●Traditional method used by many agencies	●Only population changes studied-does not capture trends such as increased commuting
District 1979 Unit Use	●Land Use ●Water Use	●Local General Plans ●Retail Agencies	●Good short-term ●Local input	●Timing of parcel development highly subjective ●General plans can have zoning imbalances
District 1975 Multi-variate	●Population ●Density ●Jobs ●Ag. Acres ●Water Use	●ABAG ●Density from general plans ●Retail Agencies	●Good long-term ●Locally developed equations	●Residential equation needs contemporary, high quality specific water use data-drought precludes current data collection ●Density is a calculated variable
IWR-MAIN	●Houses ●Jobs ●House Value ●Price of Water ●Population ●Water Use	●ABAG ●Retail Agencies ●1980 Census	●Good long-term ●Nationally developed equations	●Very detailed forecasts require lots of input data and water use data for verification ●Adjustments necessary to adapt from national to local conditions

Results of a per capita analysis of the District are presented in Appendix B. This analysis is included as an additional check to confirm that the projections from the more complex methods used in this report are reasonable. Also, per capita water use can serve as an easy comparison with other areas and agencies which currently utilize this projection method such as the California Department of Water Resources. Per capita analysis was not chosen as the major projection method to pursue because it does not provide sufficient detail for estimating water demand with changing conditions.

II. IWR-MAIN

Initially, the IWR-MAIN (Institute for Water Resources—Municipal and Industrial Needs) forecasting system was chosen as the approach to pursue. The IWR-MAIN computer model, developed for the U.S. Army Corps of Engineers, offers a number of water use projection options and predictive equations. It requires a reasonable amount of analysis to ensure the validity of projections for any given area, but the approach provides a firm basis from which to build. The equations rely on readily available variables, with the notable exception of a very high level of detail used in job projections. The two major variables are number of households and jobs. The approach has been used successfully by many agencies, including Metropolitan Water District of Southern California. Different categories of water use and several variables facilitate evaluation of factors impacting future water use. Different categories also help in evaluation of future water savings potential.

The IWR-MAIN computer model can forecast water use in four different categories (sectors); (1) residential, (2) commercial, (3) manufacturing and (4) public/unaccounted. It does not address agricultural use. For the residential sector, it uses multi-variate equations developed by multiple linear regression of cross-sectional data studied by Howe and Lineweaver (1967). For commercial and manufacturing sectors, it uses per employee coefficients, with a library of over 200 different coefficients available. The unaccounted sector can be estimated as a fixed percent of water use or by a per capita coefficient. IWR-MAIN also provides several options for forecasting future years input data.

III. THE DISTRICT APPROACH

Application of the IWR-MAIN system for this analysis was tailored based on available water use records and demographic data projections. As adapted, the methods used are somewhat similar to IWR-MAIN and also to the methods used in the District's ***1975 Master Plan***. The new method improves on the ***1975 Master Plan*** approach by incorporating variability from year to year into residential demand. It is a successful application of the IWR-MAIN approach specific to this County.

This current analysis of Santa Clara County forecasts water use in four categories: (1) residential, subdivided into single and multi-family categories; (2) commercial and industrial; (3) agricultural and (4) unaccounted. Residential use is also analyzed by two different predictive equations to reflect differences in indoor and outdoor water use. The residential equations are those used by the IWR-MAIN system. The second category is a departure from IWR-MAIN, combining its public, commercial and manufacturing categories. The residential equations were calibrated and coefficients were developed for the three nonresidential categories, as is detailed in Chapter 4. Then the equations and coefficients utilized were organized into Lotus spreadsheets to make water use calculations.

All future year input data is projected outside of the IWR-MAIN system, not utilizing IWR-MAIN's other growth models or historic trends forecasting options. As has been mentioned, IWR-MAIN typically forecasts commercial and industrial use in over 200 different sub-categories. This requires projected number of jobs in every sub-category. The program's growth models can make these future projections based on 1 year of employment data by three and four digit SIC codes and future projections of population and total employment, but early IWR-MAIN runs for Santa Clara County, as a whole, indicated that the predictions from the nationally developed growth models were not accurately reflecting the intense high technology and manufacturing employment that is unique for this County. Outside of the IWR-MAIN model, projections with this level of detail are difficult to obtain on a Countywide level and would be extremely difficult to obtain by smaller areas. Also, the water use data available to verify that the equations make accurate water demand projections is not as precise as this level of detail implies. Finally, it was judged that this implied precision in the IWR-MAIN program did not really improve the forecast itself compared with a more general forecast.

The major input data in this analysis are the number of jobs and number of households. These two variables are direct multipliers to the M&I water use equations, as is shown in Chapter 4. Chapter 3 describes the development of all the projection data, which included review of the two major variables by every city planning agency in the County. Chapter 7 discusses every variable used in the forecast before presentation of the projections. Chapter 8 includes a sensitivity analysis of all the variables in the calibrated equations which illustrates the relative importance of each variable.

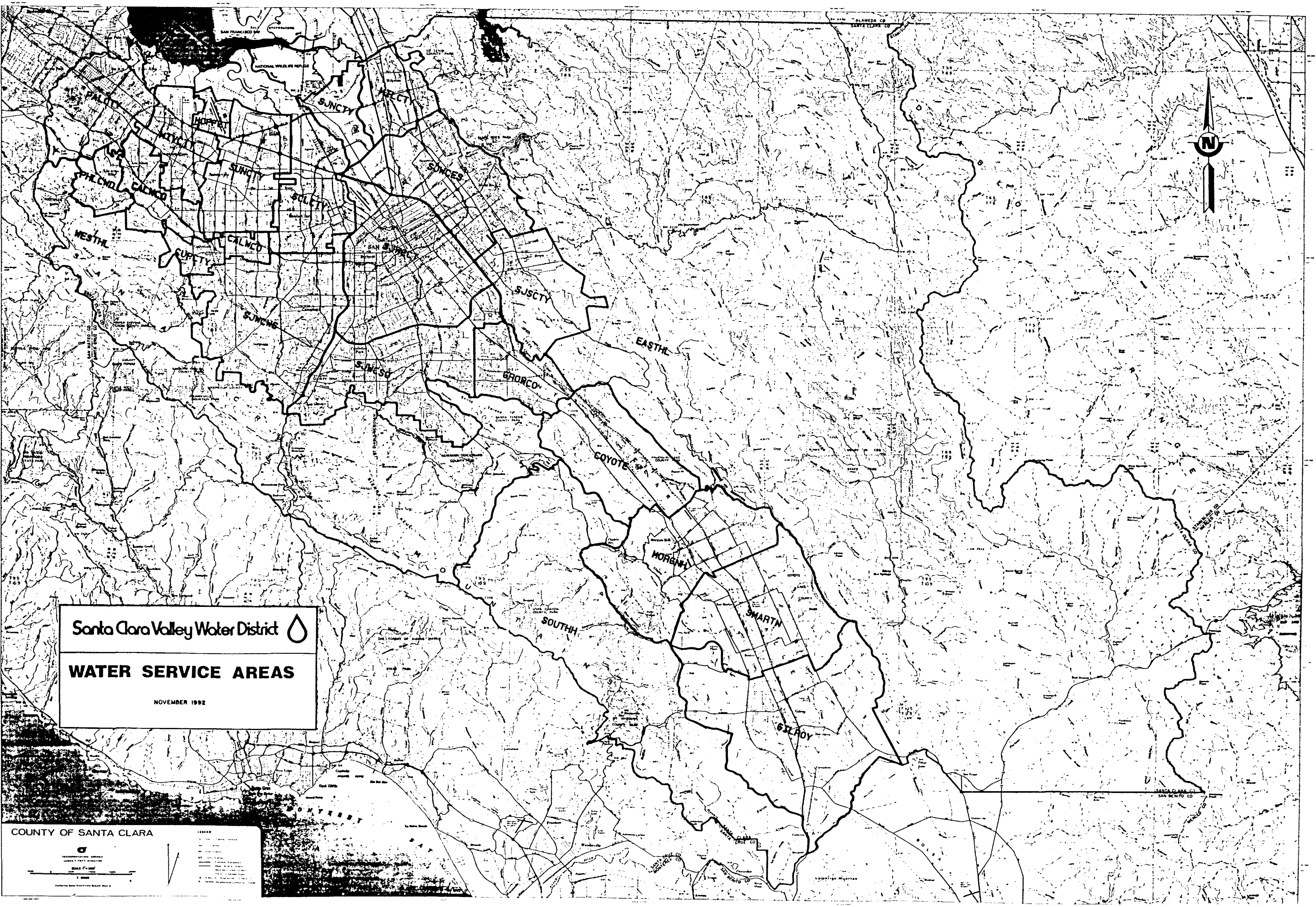
IV. WATER SERVICE AREAS

The water use projections are separated into smaller subareas within Santa Clara County for making separate forecasts for each water service area. To determine these areas, a review was made of the water retailers' current service areas, previous District Water Service Areas maps, city boundaries, maps from planning agencies such as the County and City of San Jose, and the 1980 census tracts map. The resulting water service areas are identified in Table 2-2 and shown in Figure 2-1. Santa Clara County is separated into 23 different water service areas. In north county these areas generally follow boundaries of different water retailers. In south county these boundaries generally follow census tract boundaries.

TABLE 2-2

Water Service Areas

Boundary Description	WSA
North County	
East Valley	
City of San Jose, Northern Section	SJNCTY
San Jose Water Company, Eastern Section	SJWCES
City of Milpitas	MILCTY
City of San Jose, Southern	SJSCTY
Central Valley	
San Jose Water Company, Southern Section	SJWCSO
San Jose Water Company, Central Section	SJWCCT
Great Oaks Water Company	GROWCO
West Valley	
San Jose Water Company, West Section	SJWCWS
California Water Company	CALWCO
City of Cupertino	CUPCTY
Moffett Field Service Area	MOFFET
City of Mountain View	MTVCTY
City of Palo Alto	PALCTY
Purissima Hills County Water Department	PHLCWD
City of Sunnyvale	SUNCTY
City of Santa Clara	SCLCTY
South County	
Gilroy	GILROY
Morgan Hill	MORGNH
Coyote	COYOTE
San Martin	SMARTIN



Santa Clara Valley Water District

WATER SERVICE AREAS

NOVEMBER 1992

CHAPTER 3. DATA

Data is the main driver of the water use projections and a major factor in determining the method to be used. This chapter details the data used in this study—both the historic data for development of the predictive equations and the projection data used in making the forecasts.

I. DATA FOR MODEL CALIBRATION AND VERIFICATION

Recorded water use data specific to the area is needed to ensure that the equations used are good predictors of water use for that area. Ideally, recorded water use in each different classification would be used for verification. Available recorded water use information within Santa Clara County was investigated to help define, calibrate and then verify the methods used.

A. Water Use Data

In March 1989, District staff requested water use information by different water use classifications from the County's water retailers. The District received information from nine of the 13 major retail agencies. Several retailers did not keep this type of data. Several compiled data on 1987 or 1988 specifically to meet this request but did not have this information readily available. The data received was compiled by different classification breakdowns from each different retailer not directly corresponding to IWR-MAIN sectors.

District water use records are limited in their usefulness for calibration and verification. As the District is a water wholesaler, the District only records total municipal and industrial use and total agricultural use. Consequently, District records are only helpful in checking total estimates—not estimates by different sectors of use. This poses difficulty in reviewing retail agencies' use by classifications in areas where there are privately owned wells, which report groundwater use only to the District. Also, the District records groundwater use in 6-month periods to correspond to its fiscal year—July through December and January through June. Thus, the District records cannot be used to check seasonal (winter versus summer) use.

Finally, in the southern portion of the County, total water use information has only been collected by the District since mid-1987, making a very short period of record. Throughout this period, demand has been constrained by drought conditions and various voluntary and mandatory water use reduction programs. The projections should be an improvement over past projections done without the benefit of any recorded data. However, these projections can be improved in the future when there is a greater amount of data on recorded use available for south county.

1. *City of Milpitas Billing Reports*

Monthly water use records by customer class were obtained from the City of Milpitas Utilities Department. This data was used to calibrate the water use equations for this County because it was the best record of water use by customer class available from the County's water retailers. The City of Milpitas has kept recorded use by nine different classifications since mid-1984. The classifications were grouped into residential (single and multi-family) and nonresidential categories. Another advantage of using the City of Milpitas for calibration is that there is very little private groundwater pumping in Milpitas and thus little water use that is not categorized. The number of housing units served was also obtained with the billing records. Analysis of this data is presented in detail in Chapter 4.

2. *SCVWD Records*

Total water use for north county was compiled from District records. Records from 1985-1987 were analyzed seasonally as a comparison with Milpitas' data used in the calibration and yielded a similar relationship. Corresponding outflow to the sewage treatment plants was also examined to assess the similarity of winter use and indoor water use. Total north county use was also used extensively in verifying the adapted water demand projection methodology.

B. Weather Data

As part of model verification, to accurately predict water use for a past year of record it is necessary to include the weather conditions for that year in the projections. Monthly weather data was collected for the 1980s from the National Weather Service San Jose Weather Station (SCVWD Station 86).

II. INPUT DATA

As the IWR-MAIN User's Manual points out, "the level of difficulty of the data collection effort depends, to a large extent, on the level of user sector disaggregation and the study area definition . . . the more aggregated the model, the fewer the data requirements, the greater the need for calibration against local water use . . ." (p. II-34). In other words, how much input data the model needs to make a good forecast depends on how specific a water use prediction is needed. Availability of local, regional and State sources of demographic data was researched. The data used is readily available information which is not extremely dependent on extensive manipulation and judgement. The level of disaggregation of the input data is appropriate to the available calibration data and also to the level of the projections themselves.

A. Data Sources

1. *ABAG Projections 90*

The major source of demographic data used is ***Projections 90***. ABAG estimates and projects socioeconomic data such as population, households, jobs and income based on a rigorous analysis involving regional and Countywide econometric models, time trend analysis, local policy surveys, land use and transportation optimization models, and reviews with local governments. "Projections 90 would represent the upper bound of a forecast range. That is, at least at the regional level, expected growth is not likely to exceed the levels identified . . ." (***Projections 90***, p. 9) ABAG projections also have some legal status. "In February 1978, the Governor's Office of Planning and Research (OPR) included, as part of the Urban Strategy for California, a requirement that State projects be based on OPR-approved regional agency population projections. The Governor has directed all State agencies to carry out this requirement of the State's Urban

Strategy" (***Projections 90***, p. 11). ABAG projections were obtained by census tracts from year 1980 to year 2005, in 5-year increments. ABAG has developed three sets of correspondence tables (for the years 1980, 1990, and 2005) that apportion the census tract data into city spheres of influence. Different allocation percentages can be specified for basic jobs, local jobs, and households. Similar correspondence tables were developed to apportion the census tract data into the District's water service areas. The ABAG projections by city sphere of influence were linearly extrapolated to the District's planning horizon of year 2020, and routed to the local city planning agencies for their comments.

It should be noted that ***Projections 90*** was published in December 1989 and the data by census tract was obtained in May 1990 with some adjustments from the earlier ABAG projections. In ABAG's May 1990 projections, the productivity per manufacturing employee increased. Because ABAG kept the manufacturing output the same, the number of projected jobs decreased from the December projections. When projecting manufacturing water use, the District kept the projected water use per employee constant. Rather than adjusting the water use per employee, the District used ABAG's December projections of jobs.

2. *ABAG Projections 92*

Projections 92 was in the process of being published as this report was written. The newer projections are similar to the previous projections. The population projections are slightly higher than the earlier ***Projections 90*** due to recent trends of higher birth rates and a leveling off of the drop in number of persons per household. The number of jobs is lower. This is partially due to an increase in per employee productivity, similar to the adjustment in ***Projections 90*** by census tract. Implications of these differences for water demand projections will be discussed in Chapter 8.

3. *1980 Census Data*

Several input variables came directly from the 1980 Census data. With the assistance of the State Census Data Center, the District obtained home values for owner occupied housing units and persons per unit and contract rents for renter occupied units on computer tape files by census tracts. This data was aggregated into water service areas similar to the ABAG data.

Contract rent was converted to an estimated home value using a present worth calculation assuming a traditional home loan 30 year payback period (N) and an interest rate of 15.25 percent (i), the prime rate when the census was taken, so that:

$$1980\ \textit{House Value} = \textit{Rent} * \frac{(1+i)^N - 1}{i(i+1)^N}$$

4. *1990 Census Data*

The first release of 1990 census data included the total number of housing units and population information. This information was checked to assess reasonableness of the projections used. ABAG analysis found no statistical difference between the ABAG 1990 estimates and actual census data.

5. *Department of Finance*

Estimates of the number of single-family and multi-family housing units were obtained by city from the State Department of Finance (DOF) report E-5 for years 1980, 1985 and 1990. The District estimated the percentage of single-family versus multi-family housing units based on these reports.

6. *Water Retailers*

Information on water rates and price structures were obtained from the local retail water agencies.

B. Local City Planning Agency Input

Local agency input was sought to ensure that the demographic data used for making projections is reasonable and consistent with the most current information. Letters detailing the ABAG and DOF initial data were sent to every city planning agency in the County, and District staff met with every city planning agency's staff to solicit city comments. Also, a presentation about the water demand projections was made to the Water Commission, a District advisory committee composed of representatives from each city and the County.

Some adjustments to initial data were made based on city comments. In some cases these adjustments reflected changes in city general plans made subsequent to the ABAG projections. Some changes were modifications to initial straight line extrapolation past the year 2005. Percentage adjustments were determined and applied to the census tracts within a city's sphere of influence using the District's HP3000 computer. Follow up letters to cities were sent out in July 1992 for final review. Appendix C summarizes all city comments and adjustments to initial data.

The data for number of households and jobs used in the projections is tabulated by each water service area in Tables 3-1 and 3-2 and graphed in Figures 3-1 and 3-2.

TABLE 3-1

COUNTY TOTALS FOR HOUSEHOLDS

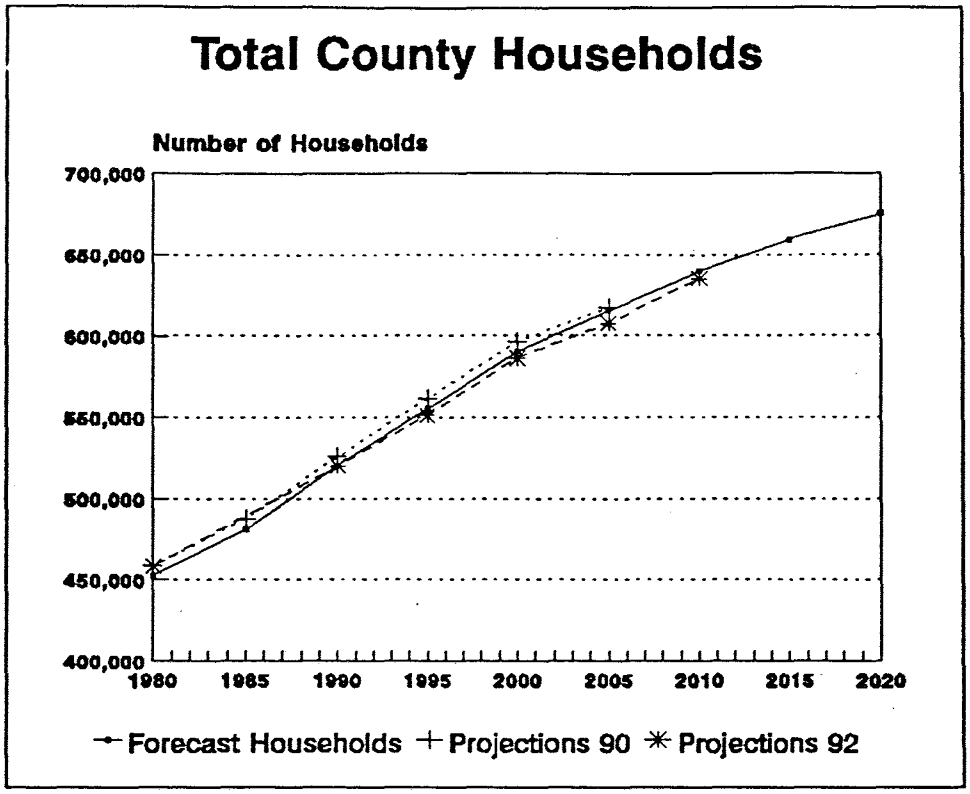
Water Service Area	1980	1985	1990	1995	2000	2005	2010	2015	2020
North County									
CALWCO	20,767	21,684	22,373	22,829	23,289	23,629	24,216	24,692	25,146
CUPCTY	4,554	5,022	5,287	5,538	5,701	5,778	5,859	5,941	6,023
GROWCO	19,355	20,335	21,469	22,233	22,705	23,111	23,311	23,337	23,242
MILCTY	10,896	11,900	13,619	15,685	17,333	17,912	18,261	18,613	18,969
MTVCTY	26,525	27,354	28,841	30,358	32,581	34,914	37,265	37,295	37,322
PALCTY	25,339	25,686	29,213	29,785	30,352	30,777	31,196	31,532	31,864
PHLCWD	2,548	2,648	2,811	2,894	2,986	3,029	3,073	3,117	3,160
SCLCTY	33,871	34,464	36,985	39,124	40,830	43,337	47,285	51,244	55,205
SJNCTY	1,654	1,811	2,627	5,123	7,756	8,301	8,772	9,169	9,504
SJSCTY	11,505	15,289	18,883	24,865	26,839	27,594	28,104	28,397	28,532
SJWCCT	76,020	80,409	85,557	89,491	95,706	98,619	100,683	101,994	102,748
SJWCES	44,882	49,354	54,133	56,853	59,087	60,777	61,924	62,597	62,910
SJWCSO	51,646	55,147	60,528	64,495	68,403	70,815	72,656	73,984	74,916
SJWCWS	65,185	66,956	69,424	71,081	72,315	73,329	74,038	74,481	74,744
SUNCTY	40,891	43,883	47,310	49,920	51,945	52,660	54,791	56,918	59,046
MOFFET	90	91	91	92	98	106	114	115	116
Total North County	435,728	462,033	499,151	530,366	557,926	574,688	591,548	603,426	613,447
South County									
GILROY	8,016	9,317	10,676	13,231	15,081	17,433	19,786	22,135	24,482
COYOTE	858	856	828	898	4,793	6,970	9,014	10,917	12,634
SMARTN	2,689	2,748	2,819	3,179	3,573	5,141	6,706	8,231	9,684
MORGNH	5,623	6,430	7,043	7,913	9,413	11,321	13,242	14,670	15,291
Total South County	17,186	19,351	21,366	25,221	32,860	40,865	48,748	55,953	62,091
County Totals	452,914	481,384	520,517	555,587	590,786	615,553	640,296	659,379	675,538

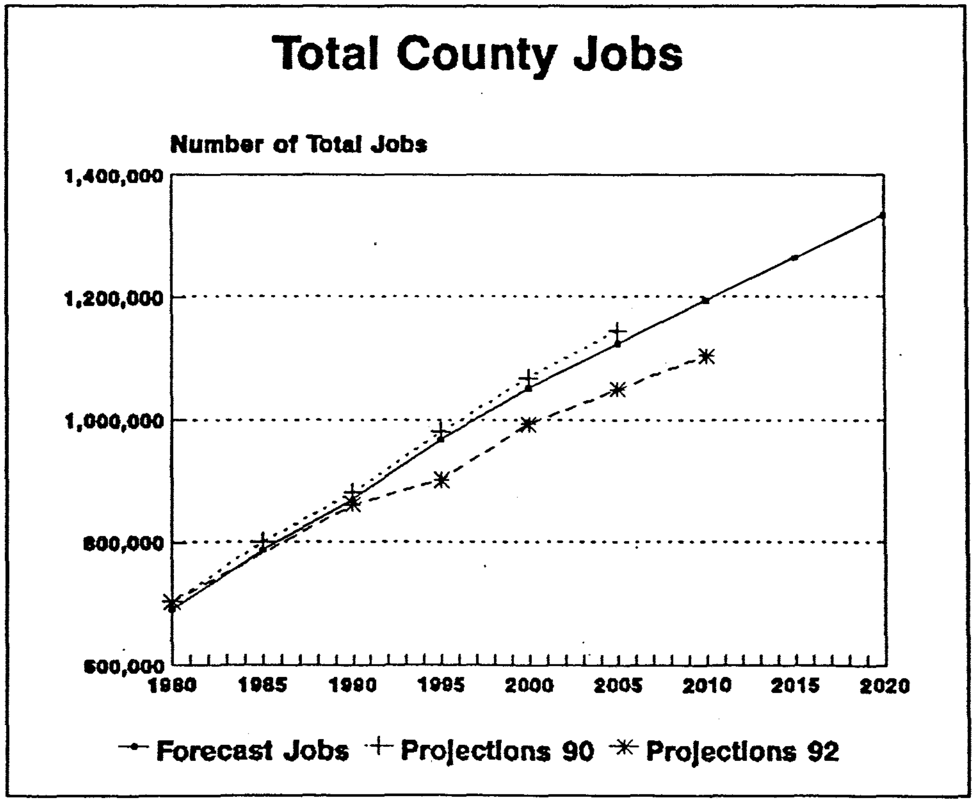
TABLE 3-2

COUNTY TOTALS FOR JOBS

Water Service Area	1980	1985	1990	1995	2000	2005	2010	2015	2020
North County									
CALWCO	33,397	36,534	37,380	40,273	41,680	43,720	46,181	48,656	51,118
CUPCTY	5,813	5,703	7,220	7,756	8,307	8,664	9,024	9,382	9,740
GROWCO	15,604	17,749	19,275	26,341	31,799	33,612	37,231	40,849	44,468
MILCTY	15,916	26,559	37,073	45,008	49,052	60,000	61,484	62,490	63,904
MTVCTY	49,457	53,445	61,041	63,016	63,021	63,614	64,178	64,742	65,305
PALCTY	64,285	69,334	74,779	76,953	78,836	80,136	81,425	82,718	84,003
PHLCWD	3,636	3,933	4,116	4,161	4,240	4,292	4,344	4,397	4,448
SCLCTY	106,873	114,645	127,675	137,916	147,296	153,924	160,439	166,988	173,503
SJNCTY	11,455	21,050	27,007	29,963	32,947	45,980	50,747	55,398	60,082
SJSCTY	5,133	5,842	7,317	13,095	15,405	19,921	22,631	25,343	28,054
SJWCCT	123,085	135,661	147,181	161,817	174,066	187,572	201,079	214,587	228,094
SJWCES	39,030	48,606	49,417	57,176	65,536	73,359	81,093	88,751	96,413
SJWCSO	26,743	30,235	33,109	36,689	38,991	41,837	44,600	47,360	50,118
SJWCWS	57,320	64,102	67,466	73,226	76,596	79,598	82,486	85,372	88,258
SUNCTY	108,660	123,220	133,115	141,086	149,248	138,921	143,937	149,177	154,231
MOFFET	8,733	9,495	5,904	6,497	7,476	7,448	7,423	7,405	7,389
Total North County	675,140	766,113	839,075	920,973	984,496	1,042,598	1,098,302	1,153,615	1,209,128
South County									
GILROY	9,045	12,721	16,646	22,361	29,826	35,868	41,909	47,951	53,992
COYOTE	638	585	4,865	14,275	22,589	25,406	28,232	31,050	33,856
SMARTN	1,190	1,092	1,411	1,578	1,630	1,858	2,088	2,314	2,545
MORGNH	5,057	6,932	7,868	9,335	14,127	19,310	24,618	29,934	35,260
Total South County	15,930	21,330	30,790	47,549	68,172	82,442	96,847	111,249	125,653
County Totals	691,070	787,443	869,865	968,522	1,052,668	1,125,040	1,195,149	1,264,864	1,334,781

FIGURE 3-1 AND 3-2





CHAPTER 4. MODEL CALIBRATION

Before the water demand model is used to make future water use projections, it is used to forecast past years' water use to verify the method's accuracy. Appropriate adjustments, as indicated by the backcast, are made to the model. The District's water demand model segregates water use into four sectors: (1) residential use; (2) nonresidential municipal and industrial use; (3) unaccounted-for water and (4) agricultural use. The calibration of the methods used to project water use in these four sectors is described in this chapter.

I. RESIDENTIAL DEMAND

Residential water use is calculated using multi-variate equations developed from IWR-MAIN. These econometric water demand equations use variables which do not require extensive manipulation or judgement to calculate.

As illustrated in Figure 4-1, the IWR-MAIN equations approximate water use over the year with separate equations for winter and summer use. The IWR-MAIN equations for winter water use do not include winter outdoor use; the summer water use equations account for all outdoor water use. Thus, it is more accurate to consider the "winter use" from these equations to be the "indoor use" and the "summer use" in excess of the "indoor use" to be the "outdoor use". In the District model, the metered and sewered unit equations are used to estimate water use for single-family homes and the flat rate and sewered unit equations are used to estimate water use for multi-family homes. The four IWR-MAIN residential demand equations used for the District demand model are shown in Figure 4-2.

FIGURE 4-1

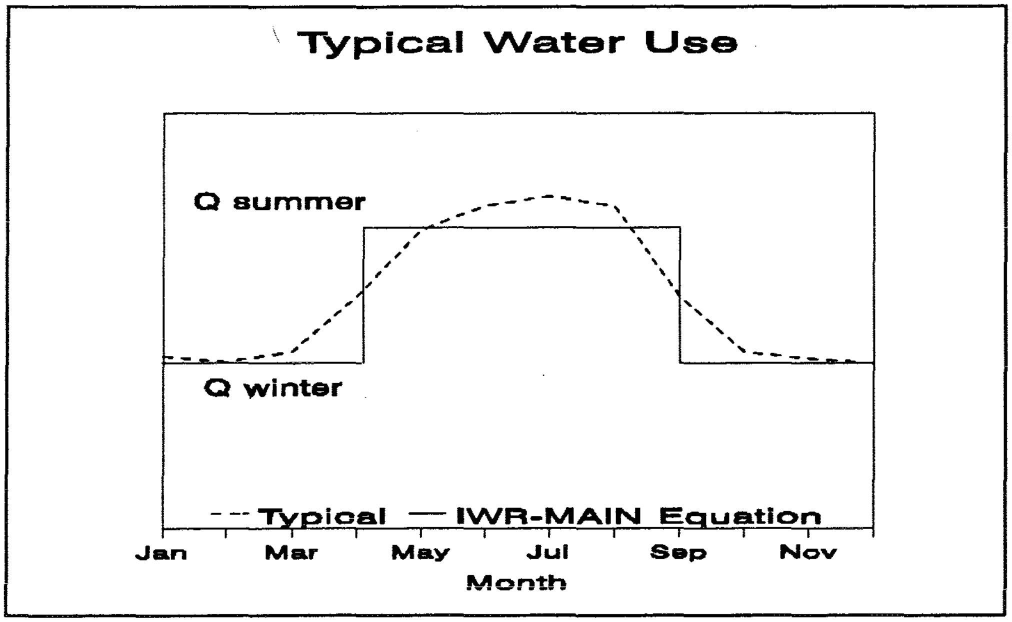


FIGURE 4-2
Precalibration Residential Equations

Winter Demand Equation for Metered and Sewered Units

Q_{winter} (Q_w) = [234 +1.451*(Home value/1000) -45.9*(Marginal price of water) -2.59*(Bill difference)] *(Number of households)

Summer Demand Equation for Metered and Sewered Units

Q_{summer} (Q_s) = [.48 *58.77 *(Marginal price of water)$^{-.703}$ *(Home value/1000)$^{.429}$] *2 *(Number of households) +Q_w

Winter Demand Equation for Flat-Rate and Sewered Units

Q_{winter} (Q_w) = [28.9 +1.5768(Home value/1000) +33.6*(Persons per household)] *(Number of households)

Summer Demand Equation for Flat-Rate and Sewered Units

Q_{summer} (Q_s) = [.41 *44.573 *(Home value/1000)$^{.783}$] *(Number of households) *2 + Q_w

Where

Home value is the 1980 census reported value in 1980 dollars
Marginal price of water is the price paid for the last unit of water in 1980 dollars
Bill difference is the calculated difference in the consumer's actual total bill and would be charged if all units of water were sold at the marginal price in 1980 dollars, as described in the IWR-MAIN User's Manual (Reference No. 9, p. I-18)

A. Prior Knowledge Adjustments

The equations in Figure 4-2 were adjusted for application in Santa Clara County. The adjustments to these equations are of two forms; (1) prior-knowledge adjustments and (2) calibration adjustments of the equation intercepts. These adjustments reflect the different relationships between water use and the IWR-MAIN explanatory variables for this region versus the nation as a whole (for which IWR-MAIN was derived). The equations have been adjusted and used successfully to predict water use in Southern California (***Municipal and Industrial Water Use in the Metropolitan Water District Service Area***, November 1987), and the adjustments made for Santa Clara County are similar.

1. Home Value Adjustments

As shown in Figure 4-2, IWR-MAIN's residential water use equations use home values to predict water use. Housing value is reflective of several determinants of water demand such as stock of water-using appliances, irrigated area, disposable income, etc. However, as the IWR-MAIN user's manual points out (p. II-86), in some areas of the country the value of homes includes substantial area premiums which have little bearing on water use. Housing values in

California, for example, have increased at a much greater rate than elsewhere in the nation and at a greater rate than other economic indicators.

Adjustments were used to make Santa Clara County home values more reflective of their impacts on water use. These adjustments were developed by Brown and Caldwell for SCVWD (Letter Report, July 1990), based on County statistics from 1960 and 1980 (see Table 4-1). San Jose Real Estate Board estimates of home value were used for the transformation since these estimates are based on actual home sales, which tend to be more accurate than owner-reported home values from the U. S. Census.

TABLE 4-1
Santa Clara County Economic Statistics

County Statistic	1960	1980
Average Home Value (San Jose Real Estate Board)	$17,772	$118,330
Median Gross Rent (U. S. Census)	$94	$451
Median Family Income (U. S. Census)	$7,417	$26,659

The adjustment for single-family residential units transforms home value by (1) discounting 1980 home values to 1960 levels [home value*($17,772/118,300)], and (2) letting them increase to 1980 levels at the rate of household income increase (which has better followed national trends than home value) [$26,659/7,417]. This transformation decreases house value by 46 percent. A similar adjustment was also developed to transform home value for multi-family units. The median contract rents, as reported in the U. S. Census, are transformed by (1) discounting 1980 median rents to 1960 median rent [contract rent*($94/$451)] and (2) letting them increase at the rate of household income to 1980 levels [$26,659/7,417].

In addition to the housing value adjustment, contract rent must also be converted to home value for use in the water use equations. Median contract rents reported in the U. S. Census are transformed to equivalent housing value using the equations

$$F=\frac{(1+i)^N-1}{i(1+i)^N}$$
$$V=RF$$

where

F = conversion factor
i = typical 1980 discount rate, in percent per month
N = 360 months
V = equivalent 1980 housing value
R = monthly rent, in dollars.

This analysis used the prime rate as reported in the April 6, 1980 San Jose Mercury News: 15.25 percent annually. This date was chosen as closest to the date of the 1980 U. S. Census.

2. *Use of Median Value to Approximate Home Value Ranges*

The IWR-MAIN program approach computes residential water use for different ranges of home value. For each range, a unit water use is computed. The total water use is the sum of the unit water use times the number of units for each house value range. To simplify the computations and data requirements, the District water demand analysis used the median house value to compute residential water use rather than using house value ranges. A preliminary investigation using City of Milpitas data showed that this approximation resulted in less than a 2 percent difference in water use compared to that computed using the home value range method.

3. *Weather Factors*

In order to compare water use records with the water demand model estimates, the estimates are adjusted to reflect actual weather conditions in the verification years.

To determine the influence of weather on water demands, monthly weather data was correlated to City of Milpitas' monthly water use data. Estimated evapotranspiration, moisture deficit, total rainfall, number of rainy days, number of days of rainfall greater than 0.1-inch, average temperature, maximum temperature, cooling degree days and heating degree days were all examined. Correlation coefficients were computed relating these weather variables and four categories of residential water use (summer and winter, single-family and multi-family housing units). For single-family residential summer use, average temperature had the highest correlation coefficient. For the other residential categories, cooling degree days showed the best correlation. Rainfall also correlated well but was not included because of high cross correlation with temperature and cooling degree days. Rainfall will be incorporated with temperature in a combination variable in future work.

Regression equations, in the exponential form of $Q = aX^b$, were derived for the highest-correlated weather variable for each of the four residential water use categories. Functions of more than one variable were not used due to high cross-correlation among the weather variables. The variable b and the correlation coefficients from the regressions are shown in Table 4-2. The variable b is then used to compute the appropriate weather factor. The weather factor is defined as

$$\left(\frac{\textit{weather variable in the verification year}}{\textit{weather variable in normal years}}\right)^{b}$$

where b is the coefficient from the exponential regression equation.

TABLE 4-2
Weather Variable Regression Results

Residential Water Use Category	Weather Regression Variable b	Correlation Coefficient
Single-family units, summer use	4.36	.83
Single-family units, winter use	1.26	.63
Multi-family units, summer use	.367	.40
Multi-family units, winter use	.813	.56

The weather factors used with the outdoor water use equations are derived from the winter and summer weather factors. To compute the outdoor use weather factor, the summer and winter weather factors were weighted by the percentages of outdoor watering that occurs in these seasons. For single-family residences, the split between summer and winter water use is 83 percent versus 17 percent, while the split for multi-family residences is 79 percent versus 21 percent. These percentages are based on the City of Milpitas water use data that was used for calibration.

Examination of the discrepancies between the 1980 to 1987 north county backcasts and recorded use suggests that more extensive work in the area of weather impacts may improve the backcasts. For example, the greatest difference between predicted and recorded water use was 5.4 percent for 1983, a year with unusual weather. In March 1983, total rainfall was very high even though temperature and number of rainy days were normal. Backcasts may be improved by use of a weather factor that is a combination of rainfall and temperature variables. This future work will also increase the precision of the forecasts for drought conditions.

B. Calibration of Residential Water Use Equation Intercepts

To calibrate the residential water demand equations, the actual water use for the calibration period was compared with the water demand predicted by the equations using the default intercepts and the prior knowledge adjustments. The intercepts were then adjusted so that the water use predicted by the equations equals the recorded water use.

1. *Single-Family Residential Intercept*

Table 4-3 shows the unit water use for single-family residences, as computed from City of Milpitas billing records from 1984 through 1988. The unit water use is computed as the total usage divided by the number of accounts billed for that month. The monthly water use by billing month is computed as one-half the bimonthly water use.

TABLE 4-3
City of Milpitas: Single Family Residences
Bimonthly Billing Records in CCF/Unit

Billing Month	1984	1985	1986	1987	1988	Average	Monthly Average
January	N/A	18.5	15.6	21.0	20.7	19.0	9.5
February	N/A	20.3	N/A	20.7	20.8	20.6	10.3
March	N/A	19.8	N/A	20.2	19.8	19.9	10.0
April	N/A	N/A	N/A	23.3	NIS*	23.3	11.7
May	N/A	N/A	24.7	27.9	NIS	26.3	13.2
June	N/A	39.7	N/A	34.1	NIS	36.9	18.5
July	N/A	38.9	37.8	32.8	NIS	36.5	18.3
August	47.7	N/A	43.5	41.2	NIS	44.1	22.1
September	39.4	32.1	36.7	37.8	NIS	36.5	18.3
October	31.8	36.0	32.4	29.2	NIS	32.4	16.2
November	22.7	26.3	27.6	26.9	NIS	25.9	12.9
December	20.7	N/A	26.4	25.0	NIS	24.0	12.0

* NIS = Not used in study, water use restrictions enforced.

Assuming that the minimum monthly water use observed is the indoor use, the indoor use based on these billing records was 10 ccf/month/unit. The water use above 10 ccf is considered outdoor use.

The economic data used by the prediction equations include 1980 home value, marginal price of water, and bill difference. For the MILCTY water service area (WSA), the 1980 median home value, as computed using 1980 U.S. Census tract data, is $92,597. The marginal price of water in Milpitas during the calibration period, expressed in 1980 dollars, is $0.55 per 1000 gallons. The bill difference is $2.35. Pricing data was de-escalated from 1986 to 1980 at a rate of 5 percent a year.

The economic data for MILCTY was used, with prior-knowledge adjustments, in the water demand equations. The resulting calibrated equations are shown in Figure 4-3.

2. *Multi-Family Residential Intercept*

The billing records for the City of Milpitas includes sections entitled multiple family residential, duplexes, and irrigation/parks/landscaping. The first two represent multi-family homes, and the third contains some multi-family water use. By comparing the addresses of the landscape accounts with county assessors lists and the city general development plan, it was estimated that 5 percent of the water use in the irrigation/parks/landscaping category can be attributed to multi-family households.

The water usage records show the number of accounts billed and water usage for each billing month. The Milpitas records also summarize the total number of accounts and units in each billing category. Since Milpitas uses bimonthly billing, the number of units that are represented by that month's billing is not the same as the total number of units. Also, since more than one unit is served by each account, the number of accounts billed is not equal to the number of units served. Therefore, a 2-month moving average of water use was computed, and divided by the total number of units to get the unit water use.

The Table 4-4 shows the unit water use for multi-family residences, as computed from City of Milpitas bimonthly billing records from 1984 through 1988. The average monthly water use, equal to one-half the bimonthly water use, is also shown.

Assuming that the minimum monthly water use observed is the indoor use, the indoor use based on these billing records was 9.0 ccf/month/unit. The water use above 9.0 ccf is considered outdoor use.

The economic data used by the prediction equations includes 1980 home value and the persons per unit. The Milpitas water use data corresponds to the MILCTY WSA. For the MILCTY WSA, the 1980 median contract rent and the persons per unit, as computed using 1980 U.S. Census tract data, are $349 and 3.24 persons per unit, respectively.

The economic data for MILCTY was used, with prior-knowledge adjustments, in the water demand equations. By comparing the predicted demand with the actual average water use, the calibrated intercepts were computed. The resulting calibrated equations are shown in Figure 4-3.

FIGURE 4-3
Calibrated Residential Equations

Indoor[1] Single-Family[3] Residential Unit Demand

$$Q_{i,sf}=205+1.451(\textit{Home value})-45.9(\textit{Marginal price of water})-2.59(\textit{Bill difference})$$

Outdoor[2] Single-Family[3] Residential Unit Demand

$$Q_{o,sf}=(0.226 * 58.77(\textit{Marginal price of water})^{-.703} * (\textit{Home value})^{.429})*2$$

Indoor[1] Multi-Family[4] Residential Unit Demand

$$Q_{i,mf}=82.0 + 1.576(\textit{Home value})\ 33.6(\textit{Persons per household})$$

Outdoor[2] Multi-Family[4] Residential Unit Demand

$$Q_{o,mf}=(0.186 * 44.576(\textit{Home value})^{.783})*2$$

where

$Q_{i,sf}$ = per unit indoor use for single-family residences, in gallons per unit per day
$Q_{o,sf}$ = per unit outdoor use for single-family residences, in gallons per unit per day
$Q_{i,mf}$ = per unit indoor use for multi-family residences, in gallons per unit per day
$Q_{o,mf}$ = per unit outdoor use for multi-family residences, in gallons per unit per day

---

[1] Indoor corresponds to "winter" in the original IWR-MAIN equations in Figure 4-2.

[2] Outdoor corresponds to "summer" (less indoor) in the original IWR-MAIN equations.

[3] Single-family corresponds to Metered and Sewered IWR-MAIN equations.

[4] Multi-family corresponds to Flat-Rate and Sewered IWR-MAIN equations.

TABLE 4-4
City of Milpitas: Multi-Family Residences Bimonthly Billing Records, in CCF/Unit Adjusted Two Cycle Averages

Billing Month	1984	1985	1986	1987	1988	Average	Monthly Average
January	N/A	17.1	N/A	17.8	18.9	17.9	9.0
February	N/A	24.0	N/A	12.2	22.5	19.5	9.8
March	N/A	N/A	N/A	23.0	NIS*	23.0	11.5
April	N/A	N/A	N/A	28.1	NIS	28.1	14.0
May	N/A	N/A	N/A	26.1	NIS	26.1	13.0
June	N/A	29.9	N/A	27.9	NIS	28.9	14.4
July	N/A	N/A	31.0	30.1	NIS	30.5	15.3
August	N/A	N/A	30.9	33.9	NIS	32.4	16.2
September	38.5	24.6	26.6	27.4	NIS	29.3	14.6
October	29.3	27.1	25.1	21.5	NIS	25.7	12.9
November	19.7	N/A	23.5	21.1	NIS	21.4	10.7
December	17.5	N/A	22.1	15.0	NIS	18.2	9.1

*NIS = Not used in study, water use restrictions enforced

II. NONRESIDENTIAL M&I DEMAND

Nonresidential municipal and industrial (M&I) water use is computed in the District model using a per-employee coefficient. Ideally, separate coefficients should be derived for different classifications of employment, but such detailed water use data and employment projections are not currently available.

A. Milpitas Data Used for Calibration

The nonresidential M&I water use for the MILCTY water service area was used to derive the employee coefficient. The water use data came from three sources: (1) City of Milpitas bimonthly billing records; (2) monthly total Hetch Hetchy water use, and (3) SCVWD M&I groundwater use (by 6-month period) within the MILCTY service area. Five of the City of Milpitas' billing categories record nonresidential use: (1) commercial; (2) industrial; (3) institutional/government/school; (4) irrigation/parks/landscaping, and (5) fire/detector checks. Five percent of the irrigation/parks/landscaping water use is assumed to be multi-family residential water use. The remaining 95 percent is nonresidential use.

Billing records by water use category were not available in all months, however. For the months with data, an average 45 percent of the Hetch Hetchy use for the month was nonresidential water use. For the months with missing data, 45 percent of the Hetch Hetchy use was assumed to be nonresidential use.

In addition to the water distributed by the City of Milpitas, there are some private groundwater wells in the area. SCVWD collects its billing data in two categories (1) municipal and industrial water use and (2) agricultural water use. All of the M&I water use from these wells is assumed to be nonresidential use. The SCVWD records for these wells record water use by 6-month period. The 6-month totals were distributed by month according to the pattern of Hetch Hetchy use over that period.

ABAG's ***Projections 1990*** gives the total number of employees by census tract for the years 1980, 1985, and 1990. This census tract data was used to derive the number of employees within the MILCTY water service area. The numbers of employees for each month were interpolated from these values.

B. Per Employee Coefficient

Table 4-5 shows the number of employees, the historical nonresidential water use, and the resulting water use per employee for the months used for the calibration. The resulting average nonresidential water use is 129 gallons per employee per day.

The bimonthly water use records were not converted to estimates of the equivalent monthly water use, so the table does not accurately show the water use for each month. However, since deriving the average daily water use sums the monthly data, this discrepancy has no effect on the accuracy of the per employee coefficient.

III. UNACCOUNTED WATER USE

In addition to the water use predicted by the nonresidential and residential equations, there is some water supplied that is unaccounted for (either losses in the system, metering errors, or unmetered use). An estimate of the unaccounted for water as a percentage of recorded water use was derived using the City of Milpitas records.

The City of Milpitas billing records were used to compute the total usage as billed. The water use, as billed, was then compared to the total Hetch Hetchy water supplied to Milpitas. The difference is the unaccounted for water use.

As with the nonresidential M&I use, the bimonthly water use records were not converted to estimates of the equivalent monthly water use so the table does not accurately show the water use for each month. However, since an average difference over the time period was all that was desired, it was not necessary to convert the bimonthly billing records to monthly estimates. The data used in the analysis is shown in Table 4-6.

For the months considered, 7.7 percent of the water supplied is unaccounted for, while 92.3 percent is accounted for (i.e., 8.3 percent of the delivered water is not in the billing records). Therefore, the predicted water use needs to be increased by 8.3 percent (7.7 percent of 92.3 percent).

TABLE 4-5
MILCTY Nonresidential Water Use Calibration

Year	Month	Employment	Nonresidential Water Use, in ccf			Use/employee in ccf
			Hetch Hetchy	SCVWD	Total	
1984	Aug	24,575	328,702	1,917	330,619	13
	Sept	25,001	183,542	1,816	185,358	7
	Oct	25,427	157,302	1,508	158,810	6
	Nov	25,852	114,174	1,349	115,523	4
	Dec	26,278	69,281	1,042	70,323	3
1985	Jan	26,704	107,585	2,203	109,788	4
	Feb	26,880	95,636	2,155	97,790	4
	Mar	27,056	104,012	2,143	106,155	4
	Apr	27,231	108,233	2,312	110,545	4
	May	27,407	140,033	2,992	143,024	5
	Jun	27,583	158,542	3,894	162,437	6
	Jul	27,759	165,116	4,046	169,161	6
	Aug	27,935	217,855	4,282	222,137	8
	Sept	28,111	159,599	4,057	163,656	6
	Oct	28,286	178,095	3,370	181,465	6
	Nov	28,462	285,456	3,013	288,469	10
	Dec	28,638	118,422	2,328	120,750	4
1986	Jan	28,814	81,018	2,792	83,810	3
	Feb	28,990	120,690	2,821	123,512	4
	Mar	29,166	108,872	2,545	111,417	4
	Apr	29,341	133,314	3,116	136,431	5
	May	29,517	123,818	3,628	127,446	4
	Jun	29,693	191,916	4,486	196,402	7
	Jul	29,869	122,097	8,952	131,049	4
	Aug	30,045	193,159	9,693	202,852	7
	Sept	30,221	191,370	9,128	200,497	7
	Oct	30,396	158,055	7,234	165,289	5
	Nov	30,572	145,676	6,831	152,507	5
	Dec	30,748	91,113	5,873	96,986	3
1987	Jan	30,924	141,022	3,917	144,939	5
	Feb	31,100	11,864	4,040	15,904	1
	Mar	31,276	179,513	3,460	182,973	6
	Apr	31,451	155,158	4,009	159,167	5
	May	31,627	162,589	5,826	168,416	5
	Jun	31,803	335,649	7,005	342,654	11
	Jul	31,979	204,349	9,399	213,747	7
	Aug	32,155	225,552	10,195	235,747	7
	Sept	32,331	207,878	9,141	217,019	7
	Oct	32,506	177,094	8,715	185,810	6
	Nov	32,682	161,632	7,190	168,822	5
	Dec	32,858	152,828	4,993	157,821	5
1988	Jan	33,034	140,637	8,401	149,038	5
	Feb	33,210	157,653	7,377	165,029	5
	Mar	33,386	112,614	8,626	121,240	4

Non-residential Water Use, per employee = 241 ccf (135 gal/day)

TABLE 4-6
Milpitas Unaccounted-for Water Use

Year	Month	Total usage (as billed) in ccf	Hetch–Hetchy deliveries		Difference in ccf
			in AF	in ccf	
1984	Sept	443,913	967	421,395	(22,518)
	Oct	324,718	944	411,285	86,567
	Nov	260,618	693	301,753	41,135
	Dec	168,841	506	220,562	51,721
1985	Jan	227,895	515	224,177	(3,718)
	Feb	193,421	503	219,246	25,825
	Mar	250,006	501	218,118	(31,888)
	apr	--	540	235,289	--
	May	--	699	304,419	--
	Jun	341,993	910	396,291	54,298
	Jul	423,296	1,027	447,440	24,144
	Aug	--	1,087	473,597	--
	Sept	289,194	1,030	448,668	159,474
	Oct	429,703	855	372,638	(57,065)
	Nov	409,466	765	333,234	(76,232)
	Dec	--	591	257,440	--
1986	Jan	181,041	596	259,618	78,577
	Feb	--	602	262,371	--
	Mar	--	543	236,679	--
	apr	--	665	289,813	--
	May	313,759	775	337,403	23,644
	Jun	402,172	958	417,209	15,037
	Jul	366,349	1,078	469,372	103,023
	Aug	415,813	1,167	508,241	92,428
	Sept	438,305	1,099	478,594	40,289
	Oct	316,900	871	379,303	62,403
	Nov	337,626	822	358,181	20,555
	Dec	222,441	707	307,926	85,485
1987	Jan	292,264	597	260,245	(32,019)
	Feb	104,758	--	268,388	163,630
	Mar	280,341	--	229,865	(50,476)
	apr	335,669	--	266,366	(69,303)
	May	354,245	--	387,070	32,825
	Jun	512,639	--	465,356	(47,283)
	Jul	432,187	--	482,712	50,525
	Aug	438,881	--	523,611	84,730
	Sept	511,879	--	469,481	(42,398)
	Oct	297,767	--	447,613	149,846
	Nov	351,590	--	369,279	17,689
	Dec	285,102	--	256,418	(28,684)
1988	Jan	273,810	--	274,954	1,144
	Feb	287,755	--	241,445	(46,310)
	Mar	254,019	--	282,322	28,303

For the months with recorded data:		
	Total billed use	11,770,376
	Total Hetch–Hetchy use	12,755,778
	Total monthly difference	985,402

Unaccounted for water, in percent of total Hetch–Hetchy use: 7.7%

CHAPTER 5. ANALYSIS AND VERIFICATION OF THE CALIBRATED MODEL

Upon calibration of the water demand equations, the water use predicted by the District model was compared with historical water use data. Two verification procedures were performed for the District demand model; (1) for north county as a whole, and (2) by water service areas (WSA) in north county. No verification of the predictive equations applicability to south county is possible since recorded water use data is not available for south county prior to 1987. Since water demand reduction measures have been in effect since 1987 due to drought, the data from years past 1987 are of very limited use for verification.

I. NORTH COUNTY VERIFICATION

The north county verification is a general method to check the accuracy of the municipal and industrial (M&I) water use equation calibrations. This verification used average data for the north county portion of the District to predict water use from 1980 through 1987 to see how the predictions compare to the actual water use.

The predictive residential water use equations from Chapter 4 use median home value, water pricing data, and the number of single-family housing units to predict single-family residential water use, median contract rent, persons per unit, and number of multi-family housing units to compute multi-family residential water use, and the number of jobs to compute nonresidential M&I use. For this verification, San Jose Water Company pricing data was used since they serve the majority of north county. As discussed in Chapter 3, the remainder of the data was derived from ABAG and 1980 census data by census tracts. Since ABAG data is only available in 5-year intervals, the data for the other years was linearly interpolated from the 1980, 1985, and 1990 ABAG data.

The predicted water use, adjusted by the appropriate weather factor for each year, was then compared with the recorded water use for the region for those years. It should be noted that the water pumped for groundwater cleanup projects in south San Jose was subtracted from the recorded water use prior to the comparison. Tables 5-1 and 5-2 summarize the input data used for the north county verification.

TABLE 5-1
Data for North County Verification

Median Home Value, $	$118,439
Price of Water, $/ccf	$0.49
Bill Difference, $	$1.98
Median Contract Rent, $	$312.67
Persons per Unit	2.36

TABLE 5-2
Time Dependent Data for North County Verification

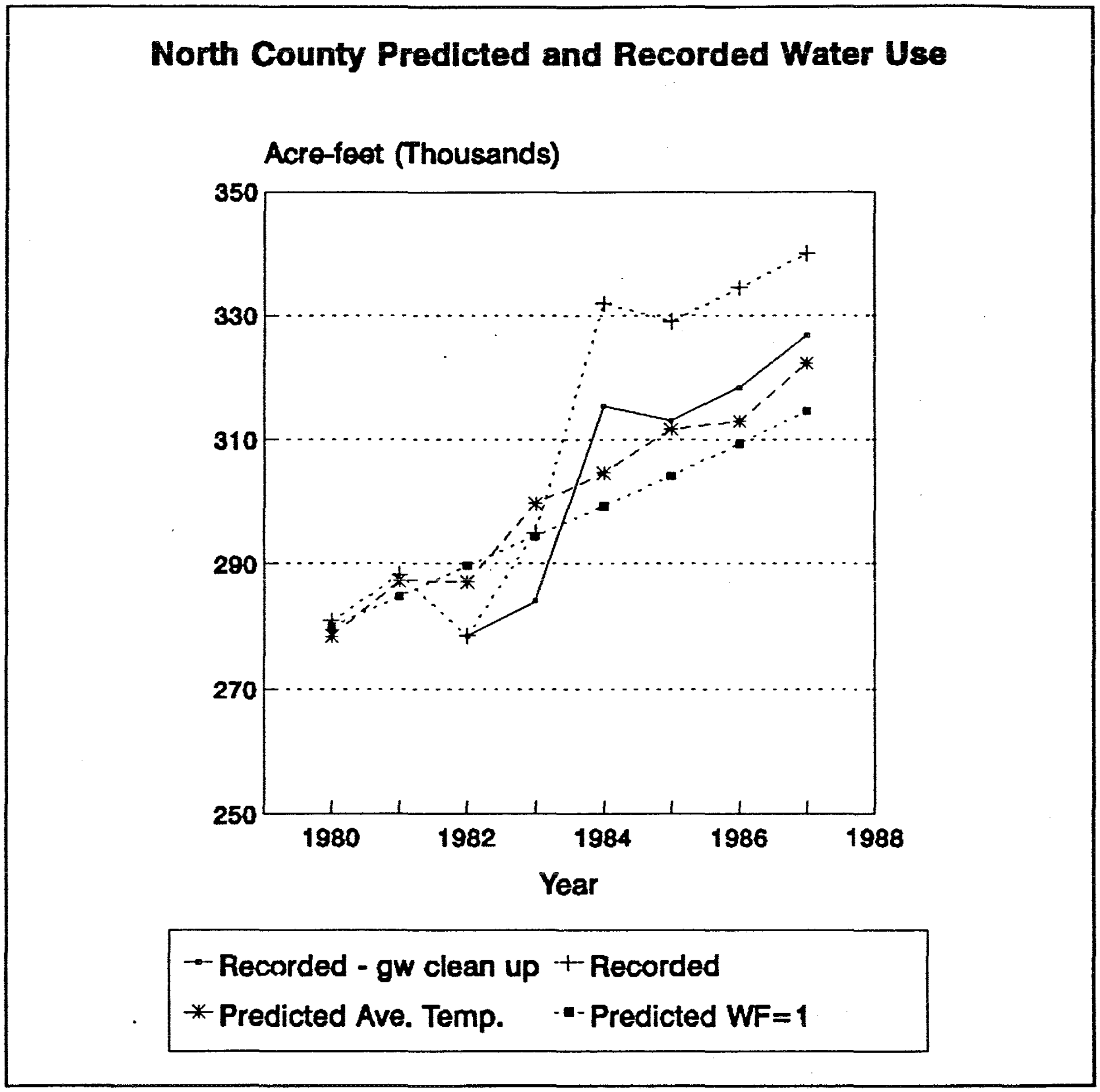
Year	Number of Single-Family Units	Number of Multi-Family Units	Number of Jobs	Recorded Water Use (acre-feet)
1980	261,106	174,071	674,780	280,885
1981	263,339	177,098	693,010	288,285
1982	265,572	180,124	711,240	278,503
1983	267,805	183,151	729,469	284,084
1984	270,037	186,178	747,699	315,410
1985	272,270	272,270	765,929	313,119
1986	276,569	276,569	780,414	318,424
1987	280,869	195,180	794,899	326,792

On average, the predicted water use agrees extremely well with recorded use. The sum predicted over the 7-year period is less than 1 percent of the recorded water use. For 1980 and 1985, the difference between predicted and recorded water use is less than 1 percent. Other years have somewhat larger errors, with the largest error being 5.3 percent in 1983. There are several possible reasons for this. First, for years other than 1980 and 1985, the number of housing units and jobs are interpolated. Second, the years with greatest error, 1982 and 1983, were years with unusually wet weather. The weather adjustment factors do not seem to adequately capture the effects of the weather in these years on water use. If greater accuracy were required, the weather adjustment could be enhanced as discussed in Chapter 4. The results of the verification are shown in Figure 5-1.

II. SUBAREA ESTIMATES

Water use projections were also separated spatially in separate forecasts for individual WSAs. To define these areas, a review was made of water retailers' current service areas, city boundaries, maps from planning agencies such as the County and the City of San Jose, and the 1980 census tracts map. Santa Clara County was separated into 23 different water service areas. In north county, these areas generally follow boundaries of different water retailers. In south county, these boundaries generally follow census tract boundaries.

FIGURE 5-1


North County Predicted and Recorded Water Use
Acre-feet (Thousands)
350
330
310
290
270
250
1980
1982
1984
1986
1988
Year
Recorded - gw clean up
Recorded
Predicted Ave. Temp.
Predicted WF=1

The data needed for the predictive equations were allocated to the WSAs by assigning census tracts (or percentages of census tracts) to each WSA. The pricing data for each WSA was based on the pricing used by the water retailer that serves that WSA. The recorded water use by WSA was derived from District records.

Table 5-3 shows the recorded versus predicted water use by WSA for 1980 and 1985. As the table shows, there is a range in the quality of the verification by WSA. The accuracy of the overall input data and of the predictions does not extend very well into such small areas. However, the sum of somewhat larger portions of north county WSAs is quite good. It should be noted that these WSA projections do verify better at this level of detail than previous District studies.

There are several possible reasons for the discrepancies in the verification by WSA. One difficulty is that the predicted water use is quite sensitive to the census tract allocations. In addition, there are some questions about the recorded water use by WSA. For example, it is difficult to assign San Jose Water Company's recorded water use among the four WSAs used to represent it. The company sometimes delivers water produced in one area for use in another, throwing off verification at finer area levels.

III. CONCLUSIONS

The verification of the calibrated equations for the north county region as a whole was quite good. However, the differences between recorded and predicted water use by WSA suggest that the method's accuracy decreases for small areas. No systematic error that may reflect a problem with the applicability of the predictive equations was found and no adjustment to the calibrated equations was indicated.

Table 5-3
Predicted and Recorded Water Use by WSA, Acre-Feet

Water Service Area	1980 Recorded	Predicted	Percent Difference	1985 Recorded	Predicted	Percent Difference
East Valley						
SJNCTY	1,793	2,455	27%	3,917	4,085	4%
SJWCES	25,898	23,867	-9%	30,550	27,026	-13%
MILCTY	6,152	7,049	13%	9,297	9,175	-1%
SJSCTY	7,748	5,481	-41%	9,916	7,034	-41%
Sum	41,590	38,851	-7%	53,681	47,320	-13%
Central Valley						
SJWCSO	16,153	25,427	36%	10,727	27,276	61%
SJWCCT	55,278	47,487	-16%	72,516	50,921	-42%
GROWCO	12,307	10,516	-17%	13,653	11,221	-22%
Sum	83,738	83,430	-0%	96,896	89,418	-8%
West Valley						
SJWCWS	42,416	35,351	-20%	39,378	37,029	-6%
CALWCO	14,742	14,844	1%	19,797	15,721	-26%
CUPCTY	3,520	2,952	-19%	2,635	3,123	16%
MOFFET	1,458	1,474	1%	1,737	1,600	-9%
MTVCTY	14,665	17,679	17%	15,550	18,574	16%
PALCTY	18,638	21,272	12%	21,605	22,201	3%
PHLCWD	1,603	1,854	14%	1,530	1,946	21%
SUNCTY	29,700	34,342	14%	29,197	37,821	23%
SCLCTY	28,814	30,772	6%	31,114	32,215	3%
Sum	155,556	160,539	3%	162,543	170,229	5%
North County	280,885	282,820	1%	313,119	306,967	-2%
South County						
GILROY	N/A	5,107	N/A	N/A	6263	N/A
MORGNH	N/A	3,354	N/A	N/A	4001	N/A
COYOTE	N/A	519	N/A	N/A	508	N/A
SMARTN	N/A	3,820	N/A	N/A	3878	N/A
South County	N/A	12,800	N/A	N/A	14649	N/A
Total County	280,885	295,620	N/A	313,119	321,616	N/A

CHAPTER 6. AGRICULTURAL DEMAND

Agricultural water use in Santa Clara County is predominantly supplied directly by the District from private wells or surface water sources. Water use information is recorded in two different water charge zones with differing agricultural characteristics. The northern zone, Zone W-2, is highly developed with only small pockets of agricultural land remaining. The District has been collecting water use information in Zone W-2 for almost 30 years. Currently, agricultural use accounts for less than 2 percent of the water use in this zone. The southern zone, W-5, is less developed and more rural in character. Over half the water use in Zone W-5 is agricultural. The District has only been collecting water use records for this zone since July 1987. Two different approaches were used to estimate agricultural water use in the two zones because of the differences in the importance of agricultural use relative to total use and water use histories.

I. NORTH COUNTY

The northern Santa Clara Valley is highly urbanized with very little agriculture remaining. Most of the remaining agricultural land is expected to be developed for municipal and industrial purposes in the future. In 1987, the last year before current drought emergency water use restrictions were implemented, agricultural water use was 6,748 acre-feet (AF) of a total water use of 345,046 AF for the zone.

To project the reduction of this agricultural use over time as land is developed, it was estimated that the 1987 recorded water use would be reduced proportional to the decrease in agricultural jobs projected by ABAG. Regression of 1980s agricultural water use and agricultural jobs showed good correlation, with R^2 of 0.78. The projected agricultural jobs in Zone W-2, reduction in agricultural water use, and total water use projected are shown in Table 6-1. It is distributed to individual water service areas proportional to 1987 recorded use. (The complete results are reported in Chapter 7, Future Water Needs Forecasts.)

TABLE 6-1
North County Agricultural Demands

Year	1987	1990	1995	2000	2005	2010	2015	2020
Agricultural Jobs, W-2	4,806	4,580	4,423	4,052	3,558	3,074	2,597	2129
Reduction in Ag., Percent	0	4.4	3.4	8.4	12.2	13.6	15.5	18.0
Reduction in Ag. Use, AF	0	317	220	521	694	680	670	657
Total Agricultural Water Use, AF	6,748	6,431	6,210	5,689	4,996	4,316	3,646	2989

II. SOUTH COUNTY

The southern portion of the County, Zone W-5, is more rural than the north. Additional development is planned in the cities of Gilroy, Morgan Hill and San Jose. However, significant portions of the zone are planned to remain open space. The majority of the water use in this zone is agricultural. The District began recording water use for the zone in 1987. In 1988, the District requested voluntary water use reductions due to drought, and mandatory restrictions have been in place since 1989. In fiscal year 1987-88, the first full year of water use records, recorded agricultural water use was 24,822 AF, 54 percent of total use in the zone and 6.5 percent of total water use in the County.

The water use records for this area deviate from past projections. A rigorous analysis was done in Zone W-5 because of this discrepancy between recorded and previously projected water use and because of the importance of agricultural water use in Zone W-5.

The methodology used to project the agricultural demand in Zone W-5 involved establishing a base use by studying aerial photographs, determining base agricultural acres and appropriate per acre coefficients, and then determining the agricultural acres converting to urban use in the future.

A. Base Acreage

The base acreage of irrigated land was estimated using Land Cover Maps developed by the State Department of Water Resources (DWR) and checked with aerial photographs of the area. The Land Cover Maps were developed from aerial color slides taken in June 1990 and verified by field inspections. Crops identified were scaled and delineated to indicate specific crops.

The acreage for specific crops were determined for the entire Zone W-5 area. The total acreage of irrigated land was determined for each of the four water service areas in the Zone (Coyote, Morgan Hill, San Martin, Gilroy). Color aerial photographs taken in October 1990 were used to check the information from the DWR. Infrared photographs taken by satellite in September 1991 were also checked for general agreement.

This amount of irrigated land identified is different from the amount determined in recording water use. One difference is that the District records water use from agricultural users for "crops which are produced for market." Some ranchette-type land is billed as nonagricultural water use. These parcels can support small amounts of nonmarket agricultural activity, such as a pasture for a horse, which would be counted by the DWR as agricultural acreage but could be recorded by the District as nonagricultural water use. Another difference is inclusion of idle land in the total irrigated land. Idle land is either land cropped in past years but not tilled at time of the investigation, or new land being prepared for crop production. Idle land is included in irrigated land for planning purposes. This inclusion was based in part on the idea that the current drought has encouraged some farmers to take fields out of production. Comparison of the later October 1990 photographs did confirm that some of this land identified as idle by the DWR went into production. In total, 6,930 acres identified as idle were included in the total irrigated acreage. Inclusion of this idle land contributes to these predictions of water use being higher than recorded data.

B. Per Acre Coefficients

Per acre coefficients are used with the irrigated acreage to estimate agricultural water demand. The coefficients were determined through investigation of metered data in Zone W-5 and comparison with available lists of crop factors.

Five potential lists of per acre coefficients were evaluated from three different sources. These lists were (1) the District's current Water Revenue factors from Worksheet B, developed over the years with information from Zone W-2; (2) a proposed adjusted list of factors from a report prepared for the District by Greg Jorgensen and Kenneth H. Solomon of the Center for Irrigation Technology, Cal State Univ, Fresno; and (3) the DWR's Evapotranspiration of Applied Water from Bulletin 113 for the San Francisco Bay, Central Coast and San Joaquin study areas. Worksheet B and Bulletin 113 are found in Appendix D.

The average per acre coefficients weighted by the individual crops base acreage from the above lists varied from 1.6 to 2.6 AF/year/acre. The 1.6 weighted average came from Water Revenue's current crop factors from Worksheet B. A weighted average per acre coefficient of 2.6 resulted from using the proposed adjusted list of factors from the report out of Cal State Univ, Fresno. The DWR per acre coefficients were distributed in between.

Data collected from the metering program in Zone W-5 for 1991 calendar year was used to establish the most accurate list of per acre coefficients for the zone. Currently, metered data in Zone W-5 is limited. There is less than 1000 acres of single crop data, and only 12 crops are represented. Mixed crops with metered data add about 2000 acres and 10 additional types of crops to the metered agricultural data in Zone W-5. The average per acre coefficients from this metered data was compared to the average per acre coefficients generated using each of the five lists of factors weighted by the acreage for each type of crop in Zone W-5. Only those crops represented in the metered data, single or mixed, were included in the comparison. This analysis supported the use of the average of the two lists from DWR's Hydrologic Regions, South San Francisco Bay and San Joaquin to get the total agricultural usage. A weighted average per acre coefficient of 1.8 AF/year/acre was the result of dividing this total agricultural usage by the corresponding irrigated acreage. The District's Water Revenue Division is conducting a study to find additional single meter crops to improve their crop factor list for Zone W-5. Water demand projections can be updated with this information in the future. The DWR and metered crop data are shown in Table D-1.

When considering the entire range of weighted per acre coefficients there is a corresponding range in base water use. In addition, the inclusion or omission of idle land stretched this range of base water use. At the low end, using Water Revenue's current crop factors with the omission of idle land, the base water use is 41,978 AF/year. On the other hand, the 2.6 AF/year weighted per acre coefficient and the inclusion of idle land calculations determine base water use as 87,841 AF/year. However, the knowledge gained through the analysis of metered data for south county gives a measure of confidence that previous studies did not have available.

C. Base Water Use

The base water use was established by applying specific per acre coefficients for each crop to the corresponding acreage for the total zone and then calculating a weighted average per acre coefficient. This weighted per acre coefficient of 1.8 AF/year/acre was used with the irrigated acreage totals from each water service area to estimate the base agricultural demand as shown in Table 6-2.

TABLE 6-2
South County Agricultural Demands—Base Year

Description	Acreage	Per Acre Coef.	Demand
Coyote	5,358	1.8	9,644
Morgan Hill	4,183	1.8	7,529
San Martin	6,414	1.8	11,545
Gilroy	17,830	1.8	32,094
TOTAL	33,785	1.8	60,813

D. Land Conversion

To project agricultural need into the future, the District estimated the acreage of the agricultural land that will convert to municipal and industrial use in the future. This was done using general plan maps of municipalities in south county; Morgan Hill, Gilroy and San Jose. Within these maps, the areas with municipal and industrial water demands were identified. The County aerial photographs covering the same areas were compared to mark those areas that are currently agricultural and differ from their future land use. The Assessor Parcel Numbers for these areas were collected. The acreage and parcel descriptions were extracted from the District's Benefit Assessment Roll database. The resulting number of acres of agricultural land converting to municipal and industrial land in Zone W-5 identified from the general plan maps is 7,040 acres, as shown in Table 6-3. The general plans for the majority of the municipalities are to the year 2010. This rate of conversion in agricultural land was extrapolated out to the year 2020 bringing the total converting acreage to 10,560.

The converting acres are divided into water service areas in the following table:

TABLE 6-3
Agricultural Land Converting to Municipal Uses by Year 2010

Coyote	Morgan Hill	San Martin	Gilroy
2,072 acres	1,406 acres	none	3,560 acres

E. Water Demand Projections

The determined base water use, per acre coefficient, and converting acreage were used to project water use using the following equation:

Water Use = Base Water Use -(Per Acre Coefficient * Number of Acres Converting)

The resulting projections are shown in Table 6-4.

TABLE 6-4
South County Agricultural Demands, Acre-Feet

Year	1990	1995	2000	2005	2010	2015	2020
Coyote	9,644	8,712	7,780	6,848	5,915	4,982	4,049
Morgan Hill	7,529	6,897	6,265	5,633	5,000	4,367	3,734
San Martin	11,545	11,545	11,545	11,545	11,545	11,545	11,545
Gilroy	32,094	30,492	28,890	27,288	25,686	24,084	22,482
Total	60,813	57,646	54,480	51,313	48,146	44,978	41,810

CHAPTER 7. FUTURE WATER NEEDS FORECASTS

This chapter discusses the current best estimate of future water use in Santa Clara County. First, it reviews primary input data and assumptions used in making the forecast. Code mandated water conservation included in the projections is detailed. Then forecasts for normal and above and below normal weather conditions are presented.

I. BASIC ASSUMPTIONS

The water use equations for municipal and industrial use (detailed in Chapter 5) and for agricultural use (Chapter 6) are used to forecast future water needs. The most basic assumption to these forecasts is that water use patterns of the future will be similar to those of the past. Future projections of the major input variables, employees and households, are used with the calibrated equations to estimate future water needs. Chapter 8 includes a sensitivity analysis and alternative investigations of potential changes from different input data assumptions.

A. Time Series Input Data

Numbers of jobs and households are the future variables used in these forecasts of municipal and industrial water needs. This input data was developed as detailed in Chapter 3.

B. Other Input Data

All other input data is assumed to stay similar to present conditions in the future. Information was developed for each water service area as detailed in Chapter 3 for house value, contract rent, percent of households which are single family, persons per unit, price of water, and bill difference.

1. House Value and Contract Rent

These variables are intended to capture the effects of several determinants of water use such as irrigated area, stock of water-using appliances, and buying power. As adjusted, these variables are tied to median income rather than housing prices (detailed in Chapter 4). In the basic future projections presented in this chapter, house value and rent for each water service area are from the 1980 census.

Although mean household income is expected to rise in the future in Santa Clara County, the impacts on water use are not certain. Household income increases are not directly disposable income increases. A portion of the increase in household income is attributable to more people working from each household. An estimate of possible increases in future household use due to increases in household income could be investigated in future work.

2. Percentage of Single Family Housing

The proportion of single and multi-family households is projected to remain similar for the basic forecast although this percentage may decrease somewhat in the future as new units are increasingly multi-family. The definition of single versus multi-family is not clear cut, there is no easy source for future estimates of this data, and the difference for water use forecasts is not highly significant. For water use estimates, the distinction is actually whether the household is metered or not. Single/multi-family distinction is only an approximation of this difference. Multi-family units can fit into this metered classification and this individual unit metering may increase in the future.

3. *Persons per Unit*

ABAG ***Projections 90*** showed a slight decrease in persons per unit in the future. ***Projections 92*** shows a very slight increase. In the basic future projections presented in this chapter, persons per unit for each water service area is from the 1980 census.

4. *Price of Water and Bill Difference*

The base forecasts assume the same price and bill difference variables as were used in the verification years. In real dollar terms (after adjusting for inflation), these variables have not increased since 1980 as much as might be expected from recent increases.

Evaluation of the response to price increases is included as an alternate evaluation in Chapter 8. The elasticities used in the water use equations were not developed or investigated for applicability specifically for this County. Also, they were developed for use where sewer charges are based on water use, which is not the case in Santa Clara County.

II. CONSERVATION FROM CHANGES IN PLUMBING CODE

For overall water supply and needs planning, conservation is included primarily as an alternative for meeting projected water needs. In making these forecasts of need, conservation measures which will occur with or without District programs is included in the projections. Specifically, plumbing code changes, which require use of lower flow showerhead and toilets, lower the projected year 2020 water use by an estimated 28,000 AF. All other water conservation measures which could result if the District implements programs is investigated outside of these demand forecasts.

Additional conservation identified outside of these projections is reported in the District's ***Draft Water Supply Overview Study***. Conservation from the implementation of the Best Management Practices agreement is estimated to be 28,000 AF by the year 2020. This is in addition to the 28,000 AF estimated savings from plumbing code changes. This brings the total expected conservation savings to 56,000 AF per year by the year 2020. This is almost 11 percent of the District's total 2020 normal water needs.

A. Showerheads

In 1981, plumbing code was changed to require use of low water using showerheads in new construction. These units use about 2 gallons per minute (gpm) rather than previous 6-7 gpm units. The resulting conservation is calculated to be 16 gallons per household per day. The water use forecasts presented in this chapter also assumes retrofit of broken units at 2 percent per year.

B. Toilets

In 1991, plumbing code was changed to require use of ultra low flow toilets in new construction. These units use about 2 gallons per flush compared with previous 7 gallon models. This results in conservation of 44.6 gallons per household per day. The water use forecasts presented in this chapter also assumes retrofit of broken units of 2 percent per year.

III. WATER FOR GROUNDWATER CONTAMINATION REMEDIATION

In the early 1980s incidents of groundwater contamination were discovered at a number of sites in the County. One method used to clean up the problem is to pump groundwater and then treat it. Over time, this flushes the contaminant out of the groundwater. As a result of clean up efforts, recorded water use in the 1980s was higher than would be expected from forecasts based on predictable activities. The historic amounts of water used in these efforts is shown in Figure 7-3. In the verification of water use predictive equations, these amounts of water use are subtracted from recorded data.

Known incidents of contamination are expected to be cleaned up in the coming years. Procedures are being implemented to avoid similar problems in the future. However, future projections include 1,000 AF of water demand for unforeseen circumstances in the total amount discussed. Water for remediation is not included in the water use graphs and forecasts presented in this chapter.

IV. RESULTS

The results of this analysis are presented by water service areas in Tables 7-1 through 7-6 and graphed by water charge zones in Figures 7-1 through 7-5. The forecasts estimate three sets of weather conditions; (1) normal and (2) one standard deviation higher and (3) one standard deviation lower than normal. Total projected demand during hot conditions for the County in year 2020 is 538,000 AF. It is 516,000 AF in normal weather years.

The graphs illustrate the historic trends and verification visually. North county has a long period of recorded water use and trends are clearly evident. The water use reductions during the current water supply shortage can also be seen. South county recorded water use has a much shorter period of complete records. The south county graphs also illustrate some difficulties in comparison of recorded and projected water use discussed in Chapter 6. Water use for idle agricultural land is included in these projections. This water is not currently being used. Also, some water for ranchette M&I use is being projected as agricultural water. Additional analysis in south county is recommended for further study when additional recorded water use data is available.

MUNICIPAL AND INDUSTRIAL WATER USE, IN ACRE-FEET

AVERAGE WEATHER CONDITIONS

Water Service Area	1980 Predicted	1985 Predicted	1990 Predicted	1995 Predicted	2000 Predicted	2005 Predicted	2010 Predicted	2015 Predicted	2020 Predicted
East Valley									
SJNCTY	2,455	4,085	5,329	6,485	7,685	9,972	10,876	11,742	12,597
SJWCES	23,867	27,026	28,860	30,689	32,492	34,060	35,464	36,728	37,897
MILCTY	7,049	9,175	11,559	13,486	14,637	16,572	16,876	17,107	17,412
SJSCTY	5,481	7,034	8,642	11,492	12,438	13,348	13,887	14,361	14,789
Sum	*38,851*	*47,320*	*54,391*	*62,152*	*67,251*	*73,952*	*77,103*	*79,937*	*82,694*
Central Valley									
SJWCSO	25,427	27,276	29,763	31,335	32,712	33,702	34,514	35,177	35,729
SJWCCT	47,487	50,921	54,452	57,488	60,841	63,490	65,934	68,196	70,330
GROWCO	10,516	11,221	11,887	13,184	14,128	14,460	15,029	15,548	16,033
Sum	*83,430*	*89,418*	*96,102*	*102,007*	*107,681*	*111,652*	*115,477*	*118,921*	*122,092*
West Valley									
SJWCWS	35,351	37,029	38,419	39,490	40,068	40,550	40,946	41,285	41,591
CALWCO	14,844	15,721	16,126	16,640	16,925	17,279	17,808	18,307	18,804
CUPCTY	2,952	3,123	3,477	3,627	3,749	3,810	3,876	3,944	4,015
MOFFET	1,474	1,600	1,007	1,105	1,268	1,265	1,263	1,260	1,257
MTVCTY	17,679	18,574	20,292	20,884	21,373	22,006	22,654	22,639	22,633
PALCTY	21,272	22,201	24,481	24,866	25,218	25,439	25,670	25,884	26,107
PHLCWD	1,854	1,946	2,049	2,075	2,112	2,125	2,139	2,155	2,172
SUNCTY	34,342	37,821	40,704	42,605	44,369	42,672	44,000	45,384	46,756
SCLCTY	30,772	32,215	35,244	37,393	39,283	40,995	43,167	45,365	47,572
Sum	*160,539*	*170,229*	*181,800*	*188,685*	*194,364*	*196,141*	*201,524*	*206,223*	*210,906*
Total W-2	282,820	306,967	332,293	352,843	369,296	381,745	394,103	405,080	415,692
South County									
GILROY	5,107	6,263	7,486	9,345	11,229	13,076	14,927	16,782	18,640
MORGNH	3,354	4,001	4,410	4,941	6,265	7,811	9,386	10,778	11,868
COYOTE	519	508	1,199	2,775	5,754	7,116	8,424	9,673	10,844
SMARTN	3,820	3,878	4,020	4,491	4,988	7,018	9,046	11,024	12,911
Total W-5	12,800	14,649	17,116	21,553	28,236	35,020	41,784	48,257	54,262
Total M&I	295,620	321,616	349,409	374,396	397,532	416,766	435,887	453,337	469,954

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TABLE 7-2

M&I Water Use in Acre-Feet, Dry Weather Conditions

MUNICIPAL AND INDUSTRIAL WATER USE, IN ACRE-FEET

DRY WEATHER CONDITIONS

Water Service Area	1980 Predicted	1985 Predicted	1990 Predicted	1995 Predicted	2000 Predicted	2005 Predicted	2010 Predicted	2015 Predicted	2020 Predicted
East Valley									
SJNCTY	2,488	4,122	5,383	6,589	7,843	10,140	11,054	11,928	12,790
SJWCES	25,045	28,321	30,281	32,181	34,042	35,655	37,090	38,370	39,548
MILCTY	7,400	9,558	11,998	13,991	15,196	17,150	17,464	17,707	18,023
SJSCTY	5,792	7,448	9,154	12,166	13,165	14,096	14,648	15,130	15,562
Sum	*40,725*	*49,450*	*56,815*	*64,927*	*70,245*	*77,040*	*80,256*	*83,135*	*85,923*
Central Valley									
SJWCSO	26,907	28,856	31,497	33,183	34,671	35,731	36,595	37,296	37,875
SJWCCT	49,294	52,832	56,485	59,615	63,115	65,833	68,326	70,620	72,771
GROWCO	11,095	11,829	12,530	13,849	14,808	15,151	15,727	16,246	16,729
Sum	*87,295*	*93,517*	*100,511*	*106,647*	*112,594*	*116,716*	*120,648*	*124,162*	*127,375*
West Valley									
SJWCWS	37,198	38,926	40,385	41,503	42,117	42,627	43,043	43,394	43,708
CALWCO	15,592	16,502	16,931	17,462	17,763	18,130	18,680	19,196	19,709
CUPCTY	3,105	3,291	3,654	3,812	3,940	4,004	4,073	4,144	4,217
MOFFET	1,475	1,601	1,009	1,106	1,269	1,266	1,264	1,261	1,259
MTVCTY	18,274	19,187	20,939	21,565	22,104	22,789	23,490	23,475	23,470
PALCTY	22,092	23,033	25,427	25,831	26,201	26,435	26,680	26,905	27,139
PHLCWD	1,945	2,041	2,150	2,179	2,219	2,233	2,249	2,267	2,285
SUNCTY	35,632	39,205	42,197	44,180	46,009	44,334	45,729	47,181	48,620
SCLCTY	31,786	33,247	36,352	38,565	40,506	42,293	44,584	46,900	49,226
Sum	*167,099*	*177,033*	*189,045*	*196,203*	*202,127*	*204,113*	*209,793*	*214,723*	*219,632*
Total W-2	295,120	320,000	346,372	367,777	384,966	397,869	410,697	422,020	432,930
South County									
GILROY	5,467	6,681	7,965	9,939	11,905	13,857	15,815	17,775	19,738
MORGNH	3,562	4,239	4,671	5,235	6,613	8,230	9,877	11,322	12,434
COYOTE	556	545	1,235	2,814	5,964	7,421	8,819	10,151	11,397
SMARTN	4,659	4,735	4,900	5,483	6,103	8,623	11,139	13,592	15,933
Total W-5	14,244	16,200	18,772	23,471	30,586	38,131	45,649	52,840	59,501
Total M&I	309,364	336,200	365,144	391,248	415,552	436,000	456,346	474,860	492,431

TABLE 7-3
M&I Water Use in Acre-Feet, Wet Weather Conditions

MUNICIPAL AND INDUSTRIAL WATER USE, IN ACRE-FEET
WET WEATHER CONDITIONS

Water Service Area	1980 Predicted	1985 Predicted	1990 Predicted	1995 Predicted	2000 Predicted	2005 Predicted	2010 Predicted	2015 Predicted	2020 Predicted
East Valley									
SJNCTY	2,425	4,052	5,282	6,393	7,545	9,822	10,717	11,576	12 425
SJWCES	22,804	25,856	27,577	29,341	31,091	32,619	33,997	35,244	36,406
MILCTY	6,744	8,842	11,179	13,047	14,153	16,072	16,365	16,587	16,882
SJSCTY	5,194	6,653	8,173	10,873	11,770	12,661	13,188	13,654	14,079
Sum	*37,167*	*45,405*	*52,210*	*59,655*	*64,559*	*71,174*	*74,267*	*77,061*	*79,792*
Central Valley									
SJWCSO	24,065	25,822	28,167	29,635	30,908	31,835	32,598	33,226	33,753
SJWCCT	45,821	49,159	52,576	55,527	58,744	61,329	63,727	65,960	68,078
GROWCO	9,996	10,675	11,311	12,588	13,519	13,840	14,404	14,922	15,410
Sum	*79,883*	*85,656*	*92,055*	*97,749*	*103,171*	*107,003*	*110,729*	*114,108*	*117,241*
West Valley									
SJWCWS	33,644	35,276	36,601	37,628	38,174	38,630	39,007	39,334	39,633
CALWCO	14,181	15,029	15,411	15,911	16,181	16,525	17,035	17,519	18,001
CUPCTY	2,816	2,972	3,318	3,460	3,578	3,637	3,700	3,766	3,834
MOFFET	1,472	1,598	1,006	1,103	1,266	1,263	1,261	1,258	1,255
MTVCTY	17,089	17,965	19,651	20,209	20,648	21,230	21,825	21,809	21,803
PALCTY	20,543	21,462	23,640	24,009	24,344	24,553	24,772	24,976	25,190
PHLCWD	1,777	1,866	1,965	1,988	2,021	2,033	2,046	2,061	2,076
SUNCTY	33,163	36,556	39,340	41,166	42,872	41,154	42,421	43,744	45,054
SCLCTY	29,844	31,270	34,231	36,321	38,164	39,808	41,872	43,961	46,059
Sum	*154,528*	*163,994*	*175,163*	*181,795*	*187,250*	*188,832*	*193,939*	*198,427*	*202,906*
Total W-2	271,577	295,054	319,428	339,199	354,979	367,010	378,935	389,597	399,939
South County									
GILROY	4,799	5,905	7,076	8,837	10,649	12,405	14,166	15,931	17,698
MORGNH	3,175	3,796	4,186	4,689	5,964	7,450	8,964	10,310	11,380
COYOTE	488	477	1,170	2,743	5,584	6,869	8,105	9,286	10 396
SMARTN	3,141	3,184	3,308	3,689	4,086	5,720	7,353	8,945	10,465
Total W-5	11,603	13,361	15,740	19,957	26,283	32,444	38,587	44,472	49,939
Total M&I	283,180	308,415	335,167	359,156	381,262	399,453	417,523	434,069	449,878

TABLE 7-4

AGRICULTURAL WATER USE

Water Service Area	1980 Recorded	1985 Recorded	1990 Predicted	1995 Predicted	2000 Predicted	2005 Predicted	2010 Predicted	2015 Predicted	2020 Predicted
East Valley									
SJNCTY	182	201	207	202	190	220	199	175	149
SJWCES	619	463	379	386	379	352	319	280	238
MILCTY	253	253	284	303	283	288	242	197	158
SJSCTY	81	56	56	88	89	95	89	80	69
Sum	1,135	973	926	979	942	955	849	733	614
Central Valley									
SJWCSO	424	288	254	247	225	200	175	150	124
SJWCCT	1,953	1,293	1,128	1,091	1,006	899	790	678	564
GROWCO	248	169	148	178	184	161	146	129	110
Sum	2,625	1,751	1,530	1,516	1,415	1,260	1,112	957	798
West Valley									
SJWCWS	909	611	517	494	443	381	324	270	218
CALWCO	530	348	286	272	241	210	181	154	126
CUPCTY	92	54	55	52	48	42	35	30	24
MOFFET	139	91	45	44	43	36	29	23	18
MTVCTY	785	509	468	425	364	305	252	205	161
PALCTY	1,020	661	573	519	456	384	320	261	208
PHLCWD	58	37	32	28	25	21	17	14	11
SUNCTY	1,724	1,175	1,020	951	862	666	566	471	381
SCLCTY	1,696	1,093	979	930	851	738	630	528	429
Sum	6,952	4,580	3,975	3,715	3,333	2,781	2,356	1,956	1,577
Total W-2	10,711	7,303	6,431	6,210	5,689	4,996	4,316	3,646	2,989
South County									
GILROY	N/A	N/A	32,094	30,492	28,890	27,288	25,686	24,084	22,482
MORGNH	N/A	N/A	7,529	6,897	6,265	5,633	5,000	4,367	3,734
COYOTE	N/A	N/A	9,644	8,712	7,780	6,848	5,915	4,982	4,049
SMARTN	N/A	N/A	11,545	11,545	11,545	11,545	11,545	11,545	11,545
Total W-5	N/A	N/A	60,813	57,646	54,480	51,313	48,146	44,978	41,810
Total County	10,711	7,303	67,244	63,856	60,169	56,309	52,462	48,624	44,799

FIGURE 7-1

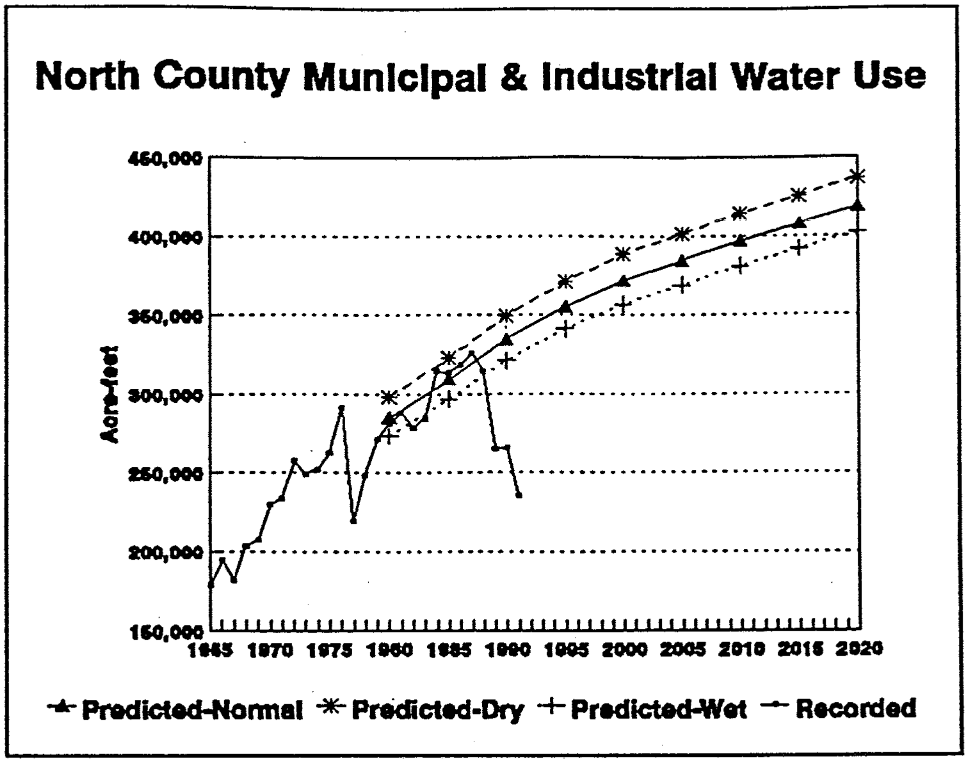


FIGURE 7-2

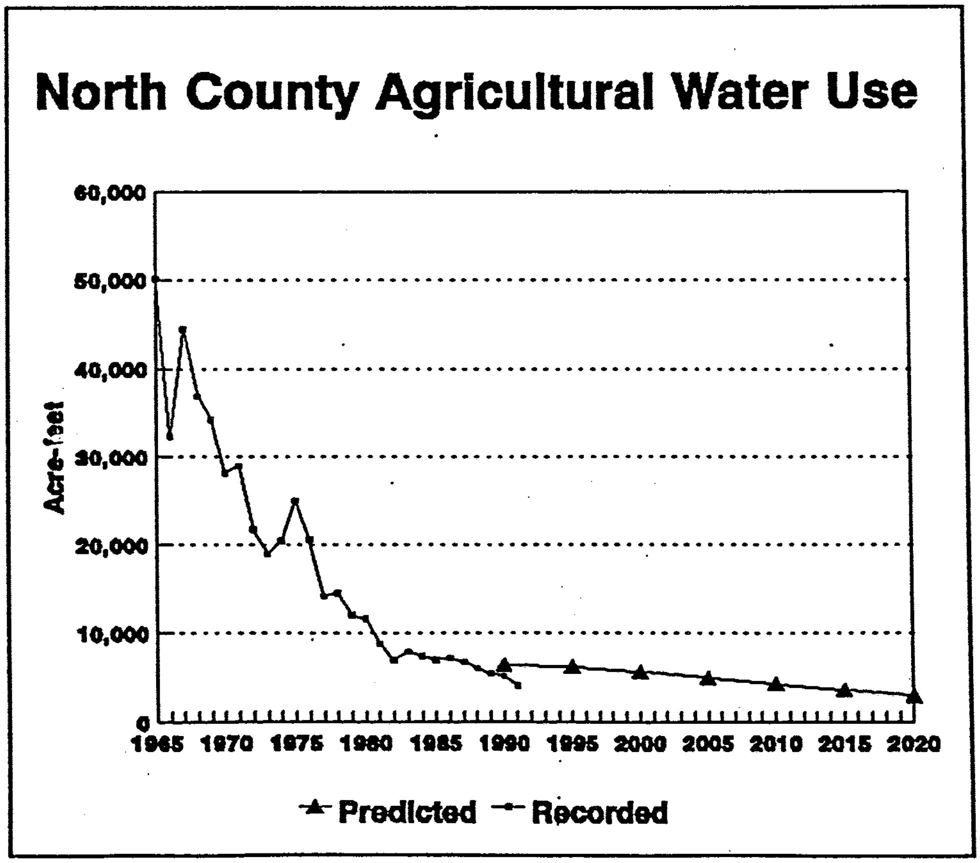
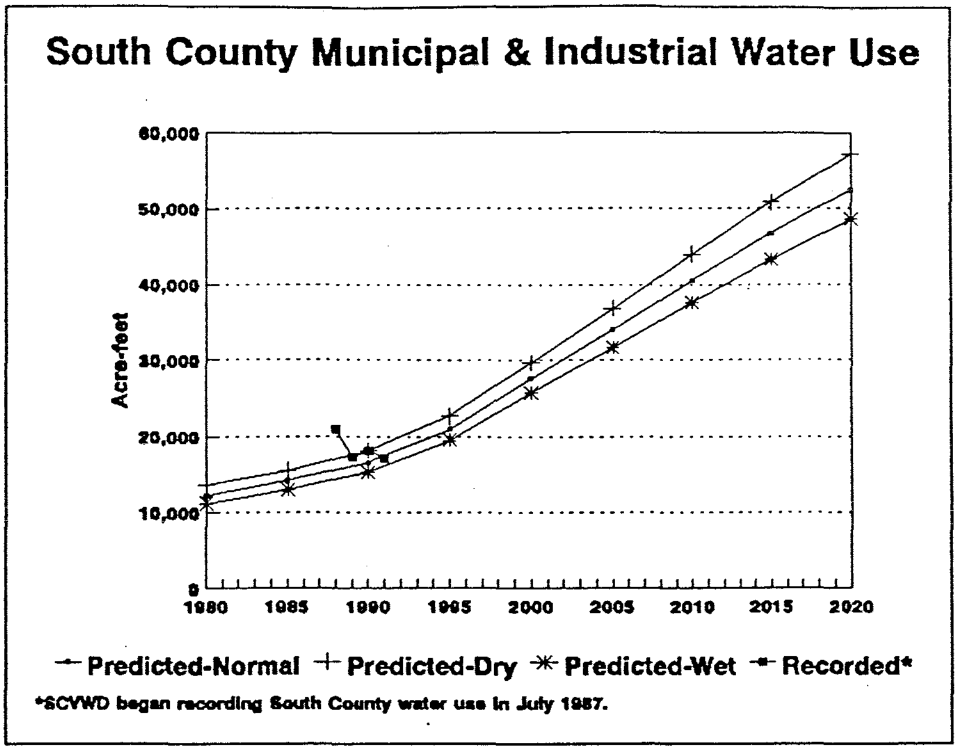
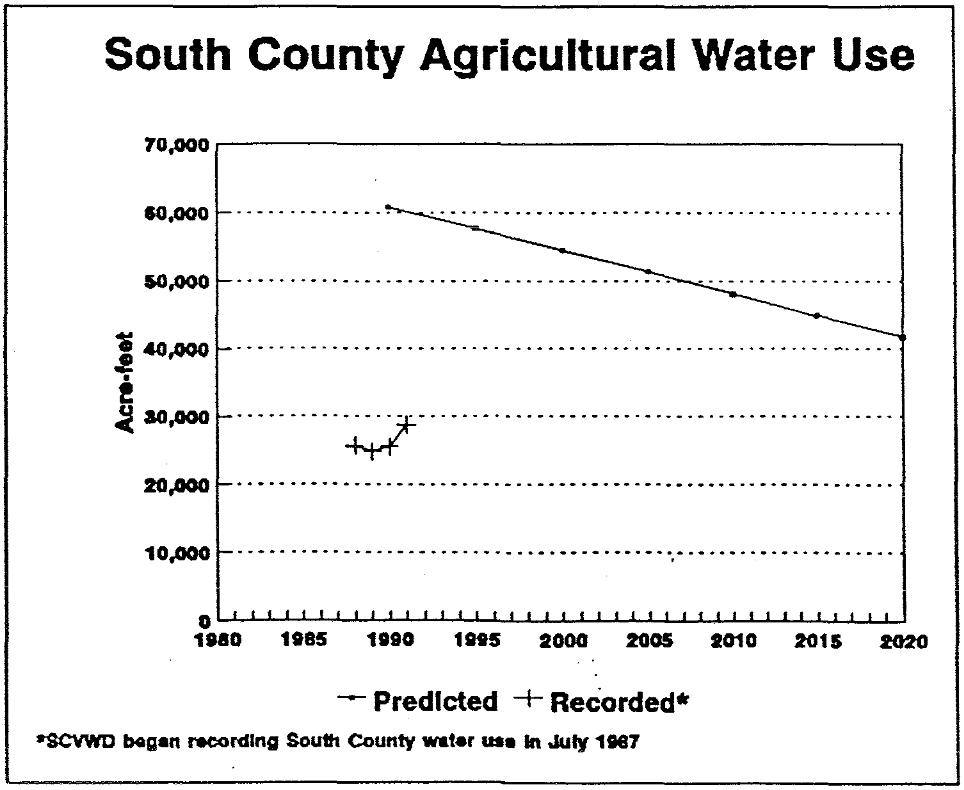


FIGURE 7-3


South County Municipal & Industrial Water Use

*SCVWD began recording South County water use in July 1987.

FIGURE 7-4


South County Agricultural Water Use

*SCVWD began recording South County water use in July 1987

TABLE 7-5
Recorded and Projected Water Needs for Average Weather Conditions

	Year	Recorded Water Use	Predicted Water Need (in AF)					
			Residential	C & I	Unaccounted	Conservation	Agriculture	Total
North County	1980	301,500	158,324	102,821	21,675	--	--	282,820
	1990	271,970	181,408	127,787	25,663	2,566	6,431	338,724
	2000	--	202,401	149,934	29,244	12,283	5,689	374,985
	2010	--	214,403	167,267	31,679	19,245	4,316	398,419
	2020	--	222,363	184,145	33,740	24,556	2,989	418,681
South County	1980	--	9,393	2,426	981	--	--	12,800
	1990	41,742	11,236	4,689	1,322	131	60,813	77,929
	2000	--	16,754	10,382	2,252	1,153	54,480	82,716
	2010	--	26,074	14,749	3,388	2,428	48,146	89,930
	2020	--	34,194	19,136	4,426	3,495	41,810	96,072
Total County	1980	--	167,717	105,247	22,656	--	--	295,620
	1990	313,712	192,645	132,477	26,985	2,697	67,244	416,653
	2000	--	219,155	160,317	31,496	13,436	60,169	457,701
	2010	--	240,477	182,016	35,067	21,673	52,462	488,349
	2020	--	256,557	203,281	38,167	28,050	44,799	514,753*

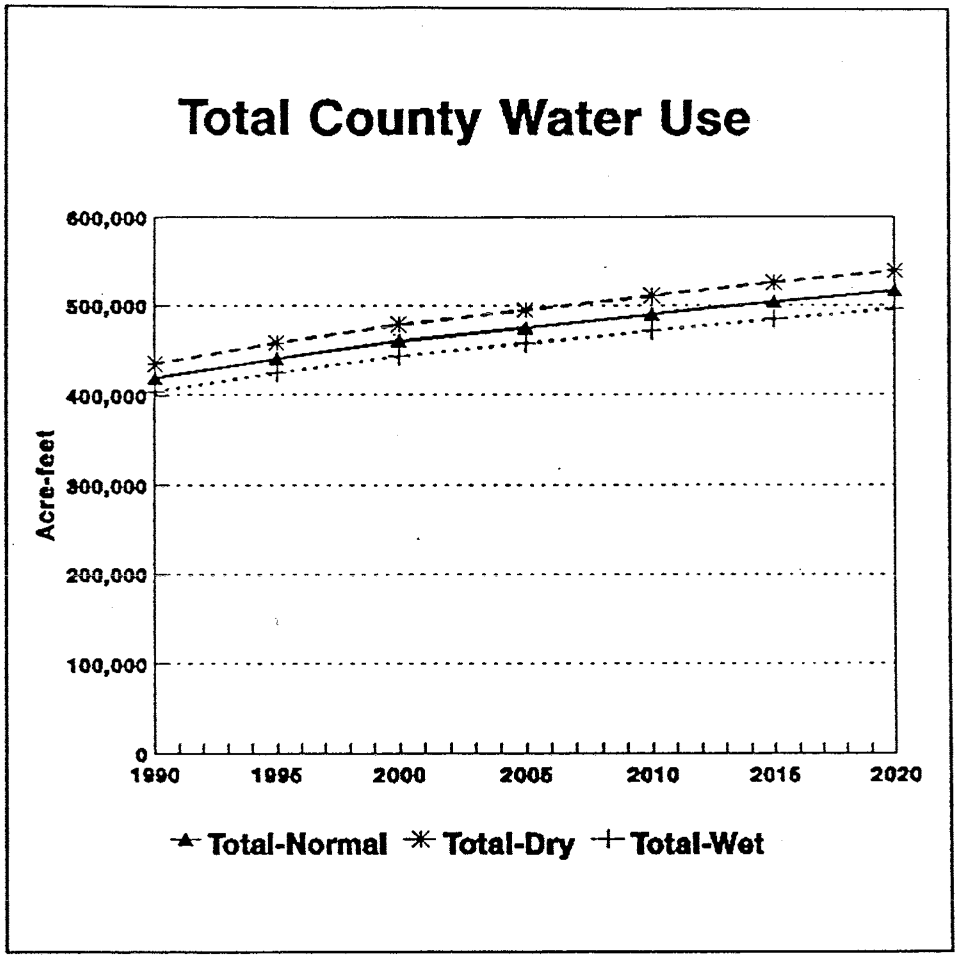
* Add an additional 1,000 acre-feet for groundwater remediation

TABLE 7-6
Recorded and Projected Water Needs for Dry Weather Conditions

	Year	Recorded Water Use	Predicted Water Need (in AF)					
			Residential	C & I	Unaccounted	Conservation	Agriculture	Total
North County	1980	301,500	169,681	102,821	22,618	--	--	295,120
	1990	271,970	194,408	127,787	26,742	2,566	6,431	352,803
	2000	--	216,870	149,934	30,445	12,283	5,689	390,655
	2010	--	229,725	167,267	32,950	19,245	4,316	415,013
	2020	--	238,279	184,145	35,061	24,556	2,989	435,919
South County	1980	--	10,727	2,426	1,092	--	--	12,800
	1990	41,742	12,765	4,689	1,449	131	60,813	79,585
	2000	--	18,924	10,382	2,432	1,153	54,480	85,066
	2010	--	29,643	14,749	3,685	2,428	48,146	93,795
	2020	--	39,032	19,136	4,828	3,495	41,810	101,311
Total County	1980	--	180,408	105,247	23,709	--	--	295,620
	1990	313,712	207,174	132,477	28,191	2,697	67,244	432,388
	2000	--	235,794	160,317	32,877	13,436	60,169	475,721
	2010	--	259,368	182,016	36,635	21,673	52,462	508,808
	2020	--	277,311	203,281	39,889	28,050	44,799	537,230*

* Add an additional 1,000 acre-feet for groundwater remediation

FIGURE 7-5


Total County Water Use
600,000
500,000
400,000
300,000
200,000
100,000
0
Acre-feet
1990
1995
2000
2005
2010
2015
2020
Total-Normal
Total-Dry
Total-Wet

CHAPTER 8. ALTERNATE EVALUATIONS

Chapter 7 presented the best estimates of future water use. Alternate forecasts were also performed to determine the sensitivity of the forecast to the various input assumptions and to evaluate several alternate assumptions. These alternate forecasts are presented in this chapter. Some of these alternates anticipate future work. This chapter also includes a discussion of recommendations for future water needs studies.

I. SENSITIVITY OF VARIABLES

Actual water requirements are highly variable, based on interaction of many different factors and future projections. These interactions and future estimates cannot be known with absolute certainty. Because water use projections rely on estimates, they also require evaluation of the range of future uncertainties.

Four alternate forecasts were made for each of the input variables used in the water demand analysis corresponding to -25 percent, -10 percent, 10 percent, and 25 percent deviations in the values of the input variable. The results of this sensitivity analysis are shown in Tables 8-1, 8-2 and 8-3. The analysis shows that, for the same percentage of input deviation, the water use forecast is by far the most sensitive to changes in the estimates of the number of housing units and the number of jobs. The forecasts are also somewhat more sensitive to deviations in the estimate of median house value than to deviations in the other input variables.

TABLE 8-1
2020 Municipal and Industrial Water Demand for Different Percent Changes in Projection Input Data

	-25%	-10%	10%	25%
Number of Jobs	414,916	447,939	491,969	524,993
Number of Housing Units	407,504	444,974	494,934	532,404
Percentage of Single Family Units	460,289	466,088	473,820	479,618
Persons per Unit	461,747	466,671	473,237	478,162
Contract Rent	460,884	466,372	473,483	478,689
House Value	453,541	463,517	474,317	485,479
Price of Water	485,628	475,498	465,097	458,767
Bill Difference	470,410	470,136	469,773	469,499
Unaccounted for Water	460,412	466,137	473,770	479,495

TABLE 8-2
Changes in 2020 Municipal and Industrial Water Demand for Different Percent Changes in Projection Input Data

	-25%	-10%	10%	25%
Number of Jobs	(55,038)	(22,015)	22,015	55,039
Number of Housing Units	(62,450)	(24,980)	24,980	62,450
Percentage of Single Family Units	(9,665)	(3,866)	3,866	9,664
Persons per Unit	(8,207)	(3,283)	3,283	8,208
Contract Rent	(9,070)	(3,582)	3,529	8,735
House Value	(16,413)	(6,437)	4,363	15,525
Price of Water	15,674	5,544	(4,857)	(11,187)
Bill Difference	456	182	(181)	(455)
Unaccounted for Water	(9,542)	(3,817)	3,816	9,541

TABLE 8-3
Percent Change in 2020 Municipal and Industrial Water Demand for Different Percent Changes in Projection Input Data

	-25%	-10%	10%	25%
Number of Jobs	-12%	-5%	5%	12%
Number of Housing Units	-13%	-5%	5%	13%
Percentage of Single Family Units	-2%	-1%	1%	2%
Persons per Unit	-2%	-1%	1%	2%
Contract Rent	-2%	-1%	1%	2%
House Value	-3%	-1%	1%	3%
Price of Water	3%	1%	-1%	-2%
Bill Difference	0%	0%	0%	0%
Unaccounted for Water	-2%	-1%	1%	2%

II. ALTERNATE FORECASTS

The analysis described above illustrates how sensitive the forecasts are to equal deviations in the input variables. Three additional alternate forecasts were performed that investigated the impacts of particular levels of uncertainties in certain input variables:

(1) Changing the water pricing variables from the 1980 pricing used in the base forecast to 1992 pricing;

(2) Changing the employment projections to those released by ABAG in May 1990 which assumes higher employee productivity and thus lower number of employees;

(3) Assuming that land currently zoned for agricultural use converts to urban use due to the pressures of high urban growth.

These alternate forecasts are described below:

A. Increases in the Price of Water

The forecasts in Chapter 7 assume that the price of water would remain constant with respect to inflation. However, the increases in the price of water since 1980 have exceeded the rate of inflation. An alternate forecast was performed using the water retailer's current (1992) pricing data deescalated to 1980 dollars. As was noted in Chapter 7, this is an alternate forecast for several reasons. The response to price given in the residential equations from IWR-Main was developed from national data and is not specific to Santa Clara County. The numbers here are an unchecked estimate of what might be a typical response to increased price of water. The results are summarized in Table 8-4.

Another thing to note is that this estimated response to price may be accounted for in expected conservation measures. The water demand presented in this report has already been reduced with the introduction of lower flow toilets and showerheads. Implementation of conservation Best Management Practices will further reduce water demand. These conservation programs can be thought of partially as a response to the higher cost of water. In the same way, this alternate forecast of response to price can be thought of as a general estimate of an amount of water people will be willing to conserve, considering the costs of water in 1992.

TABLE 8-4
Alternative Forecast Using 1990 Prices—Year 2020 Results

	Base Forecast-2020	Alternate Forecast-2020-Using 1992 Prices	Percent Difference from Base Forecast
North County, W-2, M&I only	415,692	391,933	-6%
South County, W-5, M&I only	54,262	49,145	-9%
Total	469,954	441,078	-6%

B. Decrease in Employment Projections

As discussed in Chapter 3, the forecasts presented in Chapter 7 used employment projections based on ABAG's ***Projections 90*** published in December 1989, with some adjustments based on local agency input. However, the employment projections by census tract released by ABAG in the spring of 1990 assumed a similar level of manufacturing output as the earlier projections, but with a higher productivity per manufacturing employee. Thus, the number of projected jobs decreased from the December projections. When projecting manufacturing water use, the District kept the projected water use per employee constant. Rather than adjusting the water use per employee to reflect increased productivity, the District used ABAG's December projections of jobs.

ABAG's ***Projections 92*** was in the process of being published as this report was written. The data by census tract necessary for computing water demand had not yet been released. The ***Projections 92*** forecast of employment is lower than those made in ***Projections 90***, as shown in Table 8-5. This decrease is partially due to an increase in per employee productivity, similar to the adjustment in ***Projections 90*** by census tract, and partially due to changes in the economic outlook. An estimate of potential impacts of lower future job growth was included in this study with available information.

TABLE 8.5
Alternate Year 2005 Employment Projections

	Projections 90 **as published December 1989**	***Projections 90*** **as released on diskette Spring 1990**	***Projections 92***
Santa Clara County Employment—Year 2005	1,145,950	1,097,029	1,050,230
Percent Change from ***Projections 90*** published projections	—N/A—	-4.3%	-8.4%

The alternate forecast was performed using the lower employment projections released by ABAG in 1990. Total year 2020 employment was about 25,500 jobs lower than what was used in the base forecast, primarily in north county. The difference in 2020 is less than in 2005 because the areas of high job growth are the areas least impacted by manufacturing decreases. The lower employment forecast produced less than a 1 percent reduction in the forecasted municipal and industrial water use for the year 2020. The changes in the 2020 employment and the resulting impact on forecasted 2020 water use are summarized in Table 8-6.

It is important to note that the same per-employee water use was assumed in both forecasts, even though the different levels of manufacturing employee productivity would suggest different per-employee water use. Since the appropriate adjustment to the per-employee water use was unknown, the per-employee water use was left unaltered. Future work to update base water use projections with ***Projections 92*** will need to address variable per employee water use.

TABLE 8-6
Alternate Employment Forecast—Year 2020 Results

	Base Forecast—2020		**Alternate Jobs—2020**	
	Employment	**M&I Water Use (in AF)**	**Employment**	**M&I Water Use (in AF)**
North County	1,209,128	415,692	1,184,991	411,527
South County	125,653	54,262	124,322	54,042
Total	1,334,781	469,954	1,309,313	465,569

C. Rezoning of Agricultural Land

As discussed in Chapter 6, the agricultural demands used in the base forecast were derived by computing the amount of acreage converting from agricultural use to nonagricultural use (as indicated by the general plans for Gilroy, Morgan Hill, and San Jose) and subtracting the water use from this land from the base year agricultural water use. However, these general plans assume some of the agricultural land in south county will remain as agricultural land or permanent open space preserves. Alternate forecasts were performed that assumed that the 23,228 acres of agricultural land remaining in 2020 in south county converts to municipal or industrial uses.

Depending on the type of development assumed to displace the agricultural use, the water demand in 2020 can range from approximately 6 percent less to 14 percent more than the best estimate presented in Chapter 7. Table 8-7 details this analysis, using the water use per acre factors from the District's 1979 ***Facilities Plan***. A calculation of all open space and all industrial use is included on the table only to illustrate absolute bounds. Both these situations are infeasible. A mix similar to the industrial mix currently in south county was not included in the analysis since this mix includes extremely water-intensive industries such as canning and food processing that would not remain if the area were no longer agricultural.

TABLE 8-7
Alternate Forecasts Assuming Different Zoning of Agricultural and Open Space Land

Land Use Assumed for Remaining Agricultural Land	Use Factor for that Area in AF/Yr/Acre	2020 Water Use for that Area in AF	Total 2020 Water Use in AF	Percent Difference from Base Projection
Agricultural	1.8	41,810	514,753	-NA-
Permanent Open Space Preserve	0	0	472,943	-8%
Residential (assuming low density of 3 units per acre to minimum 5-acre parcels)	0.45	10,453	483,396	-6%
Residential (assuming average densities similar to that in south county)	1.38	32,055	504,998	-2%
Residential (assuming average densities similar to that in north county)	2.6	60,393	533,336	+4%
Half Residential, Half Industrial (similar to north county)	4.98	115,675	588,618	+14%
Industrial (assuming industrial uses similar to that in north county)	7.36	170,958	643,901	+25%

III. RECOMMENDED FUTURE WORK

It is the nature of forecasting to be uncertain. This element of uncertainty does not imply that the forecasts are not good, but it does mean that improvement is always possible. In this report, a number of areas are identified where some improvement could be made in specific calculations and estimates. Many of these opportunities for future work would not have much impact on the overall forecast of water use. The estimated effort required was judged relative to the expected benefit to the overall forecast. This qualitative cost versus benefit was considered in making recommendations of which improvements to pursue for the future.

A. Periodic Updates

The most important consideration for the future is to keep demand projections contemporary. While the major source of demographic projections, ABAG, updates its information every 2 years, it is probably not essential to water supply planning to maintain quite such a responsive schedule. Large water projects are planned many years in the future because implementation takes many years of exhaustive analysis. However, it is important to establish an adequate schedule for updates, especially when large programs are in the planning phases. Even when no additional facilities or programs are expected, it is appropriate to update data with additional years of knowledge.

In updating future projections it will become necessary to evaluate commercial and manufacturing water use at a more detailed level. This is because of structural trends in business which are increasing per employee productivity. This complicates estimates of water use based on per employee coefficients. However, since projection of number of jobs is more easily estimated and readily available than projections of output, per employee coefficients may continue to be the method used for water demand forecasting.

B. Recorded Water Use Data

Water use data is collected by the District in two major categories; (1) municipal and industrial (M&I) and (2) agricultural. It is also classified into 36 other categories. However the largest of these, "water systems", account for about 85 percent of the water use. If District records further classified within this 85 percent, more extensive calibration and verification could be done for water demand forecasting. In some cases, retailers classifications are no more detailed than meter size. Collecting more detailed water use data will require a cooperative effort with the retailers in the County.

C. South County Water Use

The methods used in this study are primarily developed and verified with north county water use records. Because much less data is available on south county, the task of tailoring specially calibrated equations is more difficult and less certain. All available metered water use records were studied in developing these agricultural water use projections. However, the per acre coefficient needs to be verified as the District adds additional metered data in the coming years.

Residential water use equations which were developed with primarily suburban data need to be refined and verified for urban low density residential water use. The projections presented in this report represent an improvement over previous projections made without the benefit of any water use records, but improvements should be made in south county after the addition of several more years of water use records.

D. Significant General Plan Amendments

These projections are based on current information about future development. Currently, it is expected that some parts of the County will remain permanent urban preserves. Changes to land use zoning need to be continually monitored. General plan updates are reviewed for impacts to water supply. Major changes from open space zoning to some more water-intense commercial and manufacturing or high density residential zoning could significantly impact these projections. Impacts on water use need to be identified during the review processes as significant changes are investigated. These investigations can be limited to significant changes because periodic water use projection updates will capture the cumulative impacts of the many minor rezoning decisions made.

E. Additional Refinement of Methodology

With the addition of recorded water use by category and, along with the periodic updating of projections, additional refinements to the basic projection methods can also be incorporated in future reports. Metropolitan Water District of Southern California collected enough water use data in its 10 years of IWR-MAIN calibration efforts that they regressed original equations presented as MWD-MAIN in its Interim Report Number 4. Continual improvement of methodology and investigation of MWD-MAIN and the latest version of IWR-MAIN is recommended.

APPENDIX A. REFERENCES

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APPENDIX B. PER CAPITA ANALYSIS

Per capita analysis was the traditional method for projecting water demands for many years prior to development of more sophisticated approaches. As was discussed in Chapter 2, the method is relatively straightforward and easy to understand but it does not offer much detail to understand changes in water use. A per capita water use projection is included in this report as a general check on the more sophisticated and complicated methods used in the main study. Per capita water use can also be used as a quick comparison statistic with other agencies and areas.

North county water use records from 1965-1988 were analyzed. Water pumped for groundwater cleanup was not included. The last 3 years of record were not used because of mandatory water use reduction programs in effect. Population data for the northern cities was taken from the 1960-90 censuses and interpolated. The resulting per capita water use is graphed on Figure B-1. Per capita water use ranges from 251 to 185 gallons per capita day (gpcd). (It should be noted that per capita use in the current drought is about 180 gpcd.)

Linear regression of the 23 years of per capita data shows virtually no correlation to time ($R^2 = .01$). The regression of the two periods between droughts shows that per capita use was increasing in those periods. In 1965-1976, the correlation of per capita use to time was very good ($R^2 = .7$). In 1978-1988 per capita use did increase but the correlation to time was not good ($R^2 = .25$). The equation resulting from the entire period is:

$$\text{Per Capita Use} = 0.1578 * (\text{Year}) - 90.40$$

This gives 1990 per capita use as 224 gpcd, increasing to 228 gpcd in year 2020.

This calculation of per capita use is then combined with population projections from ABAG ***Projections 90*** to calculate total water use. In this way 2020 north county M&I water use is calculated as 415,000 AF. This checks extremely well with this study's base projection of 416,000 for average weather conditions. Applying the same per capita use in south county estimates 2020 M&I water use as 36,400 AF. Although this is noticeably lower than this study's base projection of 54,000 AF, it does serve to check the estimate. It also illustrates the limitations of per capita analysis. South county water use data is not sufficient to develop its own per capita water use coefficient, but applying the per capita coefficient developed for north county does not adequately estimate south county water use. Lower residential density contributes to higher actual water use per capita than in north county. Just a per capita analysis does not account for the difference in water use. The method selected for this study includes additional variables that are better able to estimate variations of water use.

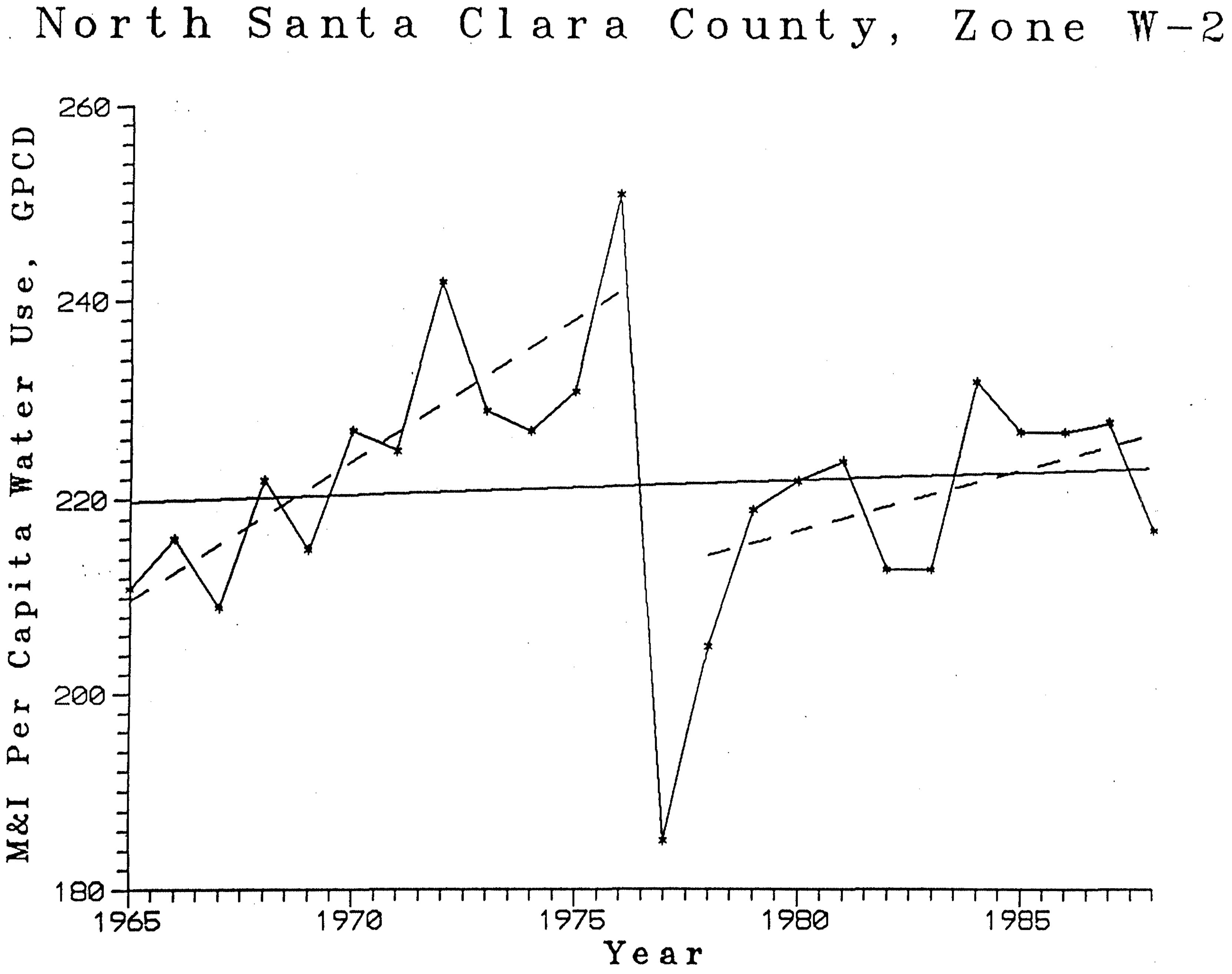

FIGURE B-1
North Santa Clara County, Zone W-2

APPENDIX C. CITY COMMENTS ON INPUT DATA

As was detailed previously, the data used for the projected number of jobs and households was primarily taken from the ABAG ***Projections 90***. ABAG demographic information projected from 1980 through 2005. Projections were initially extrapolated linearly to year 2020. The data used in determining the number of single family detached and multi-family homes was taken from the State Department of Finance (DOF) E-5 Report. This provided data through the year 1990. Initial estimates assumed that the existing ratio of single family detached homes to the number of households remained constant through the year 2020.

These initial estimates were discussed with each city planning agency. Comments and suggestions were incorporated where appropriate. The following information summarizes each city/town's review:

CAMPBELL

The City considers the data reasonable.

CUPERTINO

The City's current general plan projections are lower than the future ABAG projections. The City is presently in the process of reviewing its general plan. Additionally, Cupertino's sphere of influence includes significant portions of unincorporated area and comparisons with the City general plan are difficult.

In the current plan, there are 19,052 potential total housing units, while there are 20,950 units extrapolating ABAG projections to 2020. Proposed amendments in the current general plan review could increase the potential future projections to approximately the higher levels.

The City considered the ratio of single family detached homes to total households from the DOF 1990 Report E-5 low. The estimate was adjusted to the City's figure of 60 percent.

Since the District used the ***Projections 90*** number of jobs instead of more recent numbers, the jobs are too high. This was done to reflect a consistent output per employee in making water demand projections, as was detailed in Chapter 3.

GILROY

The City considers the initial estimates a little high but reasonable for planning future water supplies.

LOS ALTOS

The City considers the ABAG estimates for the number of households alright. Potential buildout is considered to be about 800 more units. The future extrapolation past ABAG projections was adjusted to assume buildout in 2020 at 11,500 households.

The data was also adjusted to the City's estimate of 9,084 single family detached homes in 1990 and the City's estimate of the percent of single family homes, 88 percent.

The Planning Department expects to reach buildout around 2020 with a total of approximately 12,000 jobs. The data was adjusted upward to assume this buildout in 2020.

LOS ALTOS HILLS

The Town considers all of the data fairly reasonable.

LOS GATOS

The Town considers most of the data fairly accurate. The extrapolation out to 2020 of number of single-family detached homes and total jobs was adjusted down to conform better with estimated buildout.

MILPITAS

The City considers the data a little high but fairly accurate. Staff felt that in the future the rate of change would decrease and that the straight line extrapolation to 2020 assuming the expected rate of change between 2000 and 2005 was too high. The extrapolated lines for jobs and households were adjusted down.

In final review it was noted that ABAG's preliminary ***Projections 92*** employment growth was substantially less than expected. In 2010, the preliminary number was 20 percent less than that used in these demand projections.

MONTE SERENO

The City thought that the numbers were a little high, possibly due to people working at home.

MORGAN HILL

The initial estimates of the number of households were considered a little high and the percentage of single family detached homes low. The data was adjusted according to City information.

The City considered the initial estimate of total jobs fairly reasonable. Extrapolated information past 2005 was adjusted slightly higher to correspond with City estimates.

These adjusted estimates generally agree with Morgan Hill's growth ordinance, Measure P. The numbers do not directly correspond with those called out in Measure P because they account for the larger sphere of influence area rather than just that within the City boundaries.

MOUNTAIN VIEW

The City is updating the general plan subsequent to the ABAG's ***Projections 90***. The data was adjusted in accordance with the City's future plans to increase the number of households and decrease the number of jobs from previous projections.

PALO ALTO

Based on studies done by the City, including several rezonings subsequent to ABAG's ***Projections 90***, the City considered ABAG's past and current data for jobs high.

The City also considered the number of households and single-family detached homes in the initial estimate to be low.

The initial estimates were adjusted to more closely approximate the City's current data.

SAN JOSE

The Planning Department considered the initial estimate for total jobs to be fairly reasonable.

The City Planning Department's projections for the number of households and percentage of single-family detached homes were a little lower than the initial estimates. The extrapolated household data was adjusted to the City's estimates.

SANTA CLARA

The Planning Department originally considered the estimated number of total jobs reasonable. ABAG's preliminary job forecasts for ***Projections 92*** are about 11 percent less in 2010 than those used in this demand forecast. In final review of District projections for jobs and housing, the City recommended using ***Projections 92***. Detailed data was not available at the time of this study and may be incorporated later as discussed in Chapter 7, page _.

The City updated its general plan subsequent to ABAG's ***Projections 90***. Based on the new information, the total number of households was adjusted upward. Estimates of single-family detached homes were changed from the initial constant percent to a constant number to reflect the addition of multifamily households.

SARATOGA

The City of Saratoga also uses the ABAG numbers for planning purposes and considers the data reasonable.

SUNNYVALE

The Planning Department felt that ABAG projection numbers tend to be slightly high.

Extrapolation of jobs and households past the year 2005 was adjusted to better agree with City projections of potential build out and to adjust for several changes from industrial to residential zoning.

APPENDIX D. PER ACRE COEFFICIENT FOR SOUTH COUNTY

The information in Table D-1 and Figure D-1 was used in determining a per acre coefficient for south county. Table D-1 contains the acreage of crops, metered crop factors, and the DWR's crop factors for South San Francisco Bay and the San Joaquin Valley. It also shows the development of the per acre coefficient of 1.8 AF/year/acre. Figures D-1 and D-2 are the original lists of crop factors from DWR and the District's Water Revenue, respectively.

TABLE D-1
Agricultural Water Use in South County

				Crop Factors (CF)			Water Use		
Class	Description	Total Acreage	Metered Acreage	Metered	South SF Bay	San Joaquin	Metered	South SF Bay	San Joaquin
G	Grain and hay	5,727.9			0.2	0.8		1,145.6	4,582.3
G3	Oats	218.0			0.2	0.8		43.6	174.4
G6	Misc.	141.0			0.2	0.8		28.2	112.8
F	Field crops	345.0			2.0	1.5		690.0	517.5
F2	Safflower	694.0			2.0	1.5		1,388.0	1,041.0
F5	Sugar beets	793.0	45.0	2.1	2.5	2.5	94.5	1,982.5	1,982.5
F6	Corn	1,440.0			1.8	2.0		2,592.0	2,880.0
F7	Grain sorghums	14.0			2.0	1.5		28.0	21.0
F8	Sudan	204.0			2.0	1.5		408.0	306.0
F10	Beans (dry)	232.0			2.0	1.5		464.0	348.0
P	Pasture crops	6.0	65.0	3.5	3.0	3.1	230.1	18.0	18.6
P1	Alfalfa	369.0			2.7	3.0		996.3	1,107.0
P3	Mixed pasture	68.8			3.0	3.1		206.4	213.3
P4	Native pasture	835.3			3.0	3.1		2,505.9	2,589.4
P5	Induced native	13.0			3.0	3.1		39.0	40.3
P7	Turf Farms	129.0			3.0	3.1		387.0	399.9
T	Truck and berry	476.0			2.0	1.2		952.0	571.2
T2	Asparagus	87.0			2.0	1.2		174.0	104.4
T3	Beans (green)	662.0	79.0	1.8	2.0	1.2	145.4	1,324.0	794.4
T4	Cole crops	66.0			1.1	1.2		72.6	79.2
T8	Lettuce	38.0			0.9	1.1		34.2	41.8
T9	Squash,cucumb.	638.9			2.0	1.2		1,277.8	766.7
T10	Onions, garlic	1,148.0			2.0	1.2		2,296.0	1,377.6
T15	Tomatoes	2,851.0	162.5	2.6	1.9	2.2	419.3	5,416.9	6,272.2
T16	Flowers & nursery	1,484.1			4.0	4.0		5,936.4	5,936.4
T18	Misc.	1,213.8			2.0	1.2		2,427.6	1,456.6
T19	Bushberries	52.0			2.5	2.5		130.0	130.0
T20	Strawberries	428.0	95.0	2.2	2.5	2.5	204.3	1,070.0	1,070.0
T21	Peppers	1,543.0	19.0	2.6	2.0	1.2	49.2	3,086.0	1,851.6
T22	Broccoli	5.0			1.1	1.2		5.5	6.0
D	Decid. fruits, nuts	147.0			2.2	2.6		323.4	382.2
D1	Apples	26.5			2.2	2.6		58.3	68.9
D2	Apricots	81.0			2.2	2.6		178.2	210.6
D3	Cherries	1,157.0	301.5	1.8	2.2	2.6	539.7	2,545.4	3,008.2
D5	Peaches	142.0			2.2	2.6		312.4	369.2
D6	Pears	45.0			2.2	2.6		99.0	117.0
D8	Prunes	1,103.7	42.5	0.6	2.2	2.6	26.4	2,428.1	2,869.6
D10	Misc.	181.3			2.2	2.6		398.9	471.4
D12	Almonds	9.0			2.2	1.7		19.8	15.3
D13	Walnuts	1,203.7	8.8	2.3	2.2	1.7	20.5	2,648.1	2,046.3
C	Subtropical fruit								
C6	Olives	2.0			1.5	1.8		3.0	3.6
C7	Misc.	1.0			1.5	1.8		1.5	1.8
C8	Kiwis	40.0			1.5	1.8		60.0	72.0
V	Vineyards	793.2			0.9	2.0		713.9	1,586.4
Totals		26,855.2	818.3				1,729.2	46,915.5	48,014.6
Mixed Crop Summary			2,020.5				3,956.9		
Single + Mixed Crops			2,838.8				5,686.1		
Weighted Average CF							2.00	1.75	1.79
Per Acre Coefficient								1.8	

FIGURE D-1
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EVAPOTRANSPIRATION OF APPLIED WATER*ED WATER \1
Unit (ETAW) by
Hydrologic Region
(Acre-Feet)

Major Crop or Crop Group	North Coast	North SF Bay	South SF Bay	Central Coast North	Central Coast South	South Coast	Sacra-mento Basin	San Joaquin	Tulare Lake	North Lahontan	South Lahonton	Colorado River	
Grain	1.1*	0.2	0.2	0.2	0.2	0.2	0.6	0.8	1.0	1.4	0.2	2.0	Grain
Rice	-	-	-	-	-	-	3.4	3.5	3.7	-	-	-	Rice
Cotton	-	-	-	-	-	-	-	2.5	2.5	-	-	3.3	Cotton
Sugar Beets	-	-	2.5	2.1	2.1	-	2.3	2.5	2.6	-	-	3.8	Sugar Beets
Corn	1.5	1.5	1.8	1.8	1.8	1.7	1.8	2.0	2.0	1.7	-	1.8	Corn
Other Field	1.4	1.5	2.0	1.2	1.2	2.0	1.6	1.5	1.9	1.4	2.2	2.6	Other Field
Alfalfa	2.2	1.5	2.7	2.7	2.7	2.7	2.8	3.0	3.0	2.4	4.3	5.4	Alfalfa
Pasture	2.2	2.1	3.0	2.6	2.7	2.7	3.0	3.1	3.2	2.2	4.3	5.6	Pasture
Tomatoes	-	1.5	1.9	1.8	2.1	2.3	2.1	2.2	2.3	-		2.9	Tomatoes
Other Truck	1.5	1.3	2.0	1.3	1.4	1.4	1.3	1.2	1.3	1.0	1.5	1.6	Other Truck
Almond-Pistachio	-	-	-	-	-	-	1.8	1.7	2.0	-	-	-	Almond-Pistachio
Other Deciduous	1.4	1.4	2.2	1.7	2.2	2.3	2.6	2.6	2.6	-	2.6	4.3	Other Deciduous
Citrus-Olive-Avocado	-	-	-	1.5	1.6	1.7	1.3	1.8	1.9	-	-	4.3	Citrus-Olive-Avocados
Grapes	0.8	0.8	0.9	1.1	1.3	1.5	1.8	2.0	2.1	-	-	3.0	Grapes
DOUBLE CROP:													DOUBLE CROP:
Grain-Field	2.0*	2.0*	-	2.2*	2.2	2.2	2.7	2.9	3.4	-	-	3.5	Grain-Field
Grain-Truck	-	-	-	2.2*	2.2	2.2	2.7	2.9	3.3	-	-	3.5	Grain-Truck
Truck-Truck	1.2	-	2.4*	2.4*	2.2	2.0	2.4	2.9	3.2	-	-	3.2	Truck-Truck
OTHER MAJOR CROPS:													OTHER MAJOR CROPS:
Lettuce	-	-	-	0.9	1.0	1.0	-	1.1	1.1	-	-	1.3	Lettuce
Potatoes	2.0	-	-	1.3	-	-	-	1.6	1.6	-	-	-	Potatoes
Broccoli & Cole	-	-	1.1	1.2	1.3	-	-	-	-	-	-	-	Broccoli
Nursery	-	-	4.0	4.0	4.0	-	-	-	-	-	-	-	Nursery
Date Palm	-	-	-	-	-	-	-	-	-	-	-	7.0	Date Palm
Melons	-	-	-	-	-	-	1.4	1.5	1.6	-	-	1.6	Melons

*Reflects inland temperatures NOTE: Central Coast North includes Gilroy, Hollister, and Salinas Valley areas (inland coastal valleys)

\1 - Crops use some winter and spring rainfall for their growth.
DWR has used the term Evapotranspiration of Applied Water (ETAW) toto estimate the portion of crop water use provided by irrigation water. ETAW is the ET, minus the effective precipitation (or that portion of of rainfall stored in the soil for crop use).

NOTE: Some Regions have a wide range of ETAW values for each crop because they traverse a number of climate zones. Each DAU crop value used, although not the same as the value shown in this table, should be similar.

FIGURE D-2
Current Water Revenue Factors

TABLE OF APPLIED WATER FACTORS - USE ONLY FOR CROP FACTOR METHOD

		Acre-Feet Per Acre/Per Year
(77)	BERRIES	4.1

FORAGE

		Acre-Feet Per Acre/Per Year
(0)	Alfalfa	1.3
(6)	Barley	0.7
(2)	Pasture (Hay)	1.7

NURSERY PRODUCTS

		Acre-Feet Per Acre/Per Year
(1)	Christmas Trees	1.2
(18)	Eucalyptus	1.3
(32)	Flowers	4.0
(13)	Flowers (For seed)	2.0
(88)	Ornamental Plants	1.3
(37)	Rose Bushes	5.5
(14)	Sod	3.5

ORCHARDS

		Acre-Feet Per Acre/Per Year
(25)	Apples	2.1
(16)	Apricots	1.0
(17)	Cherries	2.2
(3)	Kiwi	2.4
(19)	Peaches	1.5
(20)	Pears	2.1
(21)	Pears (Prickly)	2.1
(15)	Persimmons	1.7
(22)	Prunes	1.4
(23)	Vineyards (Grapes)	0.7
(24)	Walnuts	1.2
(26)	Mixed Orchard	1.3

TRUCK CROPS

		Acre-Feet Per Acre/Per Year
(33)	Artichokes	1.7
(4)	Asparagus	2.5
(62)	Beans, pole	1.4
(86)	Beans, bush	1.5
(29)	Broccoli	2.0
(57)	Cabbage	2.0
(31)	Carrots	1.7
(56)	Cauliflower	1.5
(59)	Celery	4.0
(5)	Chinese cabbage	1.2
(7)	Corn, corn nuts	2.0
(8)	Corn, silage	1.0
(60)	Corn, sweet	2.2
(61)	Cucumbers	2.5
(9)	Garlic	1.8
(27)	Herbs (Indoor)	3.7
(28)	Herbs (Outdoor)	2.4

TRUCK CROPS (Cont)

		Acre-Feet Per Acre/Per Year
(10)	Jojoba	0.7
(68)	Lettuce	1.8
(12)	Mushrooms	3.0
(70)	Onions (Dry)	2.1
(65)	Onions (Green)	3.7
(71)	Peppers	2.4
(72)	Pumpkins	1.2
(48)	Squash	1.0
(76)	Sugar Beets	1.7
(78)	Tomatoes, bush	2.0
(49)	Tomatoes, pole	2.8
(81)	Mixed Row Crop	2.1

OTHER

(87)	Bean Sprouts
(35)	Lakes and Ponds
(11)	Spray Water

APPENDIX E. WEATHER ADJUSTMENTS FOR USE IN SIMULATIONS MODELING

Annual water use is affected to some degree by the weather during the year. For example, people water their lawns more during a hot summer than during a cool foggy summer.

As described in Chapter 4, monthly weather data was correlated to water use data to determine the influence of different weather indicators on outdoor water use. Weather variables evaluated included evapotranspiration, moisture deficit, rainfall, number of rainy days, average temperature, maximum temperature, heating degree days, and cooling degree days. Degree days are a measure of the departure of the mean daily temperature from a base temperature of 65° Fahrenheit. Cooling degree days measure the number of degree days above the base temperature; heating degree days measure the number of degree days below the base temperature.

For the Water Needs Study, regression equations of the form $Q = aX^b$ were derived for the highest-correlated weather variable for each of four residential water use categories; single-family summer use, single-family winter use, multi-family summer use, and multi-family winter use. Average temperature was the weather variable that correlated best with single-family summer water use and was used for this category. The water use for each of the other three categories correlated best with cooling-degree days, so cooling-degree days were used for these categories.

The variables b from the regression analysis, the long-term averages of the weather variables over the historical record, and the values of the weather variables in a particular year can then be used to derive the weather factors for each category for that year. The weather factors used with the outdoor water use equations are computed from these summer and winter weather factors and the percentages of outdoor watering that occurs in these seasons. The outdoor water use predicted by the IWR-MAIN equations can then be adjusted for weather by multiplying the water use by the appropriate weather factor.

What the weather in any future year will be is uncertain. To address the influence of weather, the Water Needs Study includes three sets of projected water needs for future years; average, high water use weather, and low water use weather. The average weather condition is based on the long-term averages of the weather variables used. The high and low conditions correspond to values of the weather variables that are one standard deviation higher than the average and one standard deviation lower than the average, respectively.

Simulations Modeling

In the District's water resources planning, the responses of project alternatives in some future year are evaluated using the classic deterministic method. To enable the results of this study to be used in such water supply simulations, two different approaches were pursued.

Rainfall-based Weather Factors

The District is currently investigating water supply alternatives with a simulation model that uses stochastically-generated hydrology based on historical rainfall data for San José. To facilitate the use of water needs that vary with weather in this model, the weather factor analysis was repeated using rainfall rather than the temperature variables.

The weather adjustments to water demand using the rainfall-based weather factors were quite small—too small to explain the historical variations in water use resulting from weather. Since the component of water demand most sensitive to weather is outdoor summer water use and rainfall in Santa Clara County is predominately a winter phenomenon, the correlations between outdoor water use and rainfall were not sufficient to produce meaningful weather factors. The rain that falls in winter is not a good indicator of how much people will irrigate their landscaping during the dry summer months.

Temperature-based Weather Factors for Historical Years

The historic hydrologic record is used in the classical approach to water resources planning simulation modeling. To do that, one of the pieces of information that is needed is what that future year's water demand will be assuming that some historical hydrology and climatology will be repeated in that future year.

The District's simulations modeling commonly uses 1967 through 1992 historical hydrology. To support this effort, municipal and industrial water demand adjustments were computed based on historical weather data for these years. Table 1 shows the values of the weather variables and the resulting outdoor use weather factors.

For the Water Needs Study, data from the years 1912 to 1987, with some gaps due to unavailable data, were used to derive the weather factors equations. The average summer temperature and winter cooling degree days for these years was 64.55 degrees and 4.55 degree-days, respectively. For the period 1967 through 1992, however, the average summer temperature and winter cooling degree days were 66.27 degrees and 5.46 degree-days, respectively. Because most of the years 1967 through 1992 were warmer than the long-term average used to derive the weather factor equations, most of the weather factors in Table 1 are greater than 1.

Table 2 presents multipliers to adjust for weather the total M&I water needs for each Water Service Area for the year 2020 (as shown in Table 7-1 of the Water Needs Study report). Table 3 presents the resulting 2020 demands as adjusted for historical weather conditions. Forecast years other than 2020 will have different multipliers since the development mixes (residential to nonresidential, multi-family to single-family) change with time.

TABLE 1

Weather Variables and Weather Factors for the Years 1967-1992

Year	Winter Season	Summer Season		Outdoor Use Weather Factors	
	Cooling Degree Days	Temperature	Cooling Degree Days	Single-family Water Use	Multi-family Water Use
1967	4	65	106	1.03	1.08
1968	4	66	82	1.09	1.03
1969	0	66	90	1.08	1.04
1970	1	65	90	1.02	1.04
1971	3	64	86	.964	1.04
1972	6	66	93	1.09	1.06
1973	3	67	94	1.15	1.05
1974	1	65	77	1.02	1.02
1975	6	64	66	.972	1.00
1976	1	66	92	1.08	1.05
1977	7	65	77	1.03	1.03
1978	4	66	86	1.09	1.04
1979	10	66	95	1.10	1.07
1980	9	65	56	1.04	.988
1981	0	67	92	1.14	1.04
1982	3	65	58	1.02	.978
1983	4	67	114	1.15	1.09
1984	4	67	125	1.15	1.11
1985	3	68	121	1.22	1.10
1986	10	67	93	1.17	1.07
1987	6	68	110	1.23	1.09
1988	13	68	124	1.24	1.13
1989	7	67	98	1.16	1.07
1990	6	68	122	1.23	1.11
1991	8	66	86	1.10	1.05
1992	19	69	138	1.33	1.17

Table 2. Weather Multipliers for M&I Water Needs for the Year 2020

WSA	1967	1968	1969	1970	1971	1972	1973	1974	1975
East Valley									
SJNCTY	1.0026	1.0041	1.0038	1.0016	0.9994	1.0048	1.0070	1.0010	0.9990
SJWCES	1.0081	1.0116	1.0110	1.0048	0.9988	1.0139	1.0197	1.0030	0.9972
MILCTY	1.0051	1.0094	1.0087	1.0031	0.9979	1.0108	1.0161	1.0023	0.9974
SJSCTY	1.0107	1.0138	1.0133	1.0062	0.9993	1.0170	1.0235	1.0037	0.9969
Sum	1.0071	1.0104	1.0098	1.0042	0.9988	1.0124	1.0177	1.0027	0.9975
Central Valley									
SJWCSO	1.0124	1.0159	1.0152	1.0072	0.9993	1.0195	1.0270	1.0043	0.9964
SJWCCT	1.0072	1.0092	1.0088	1.0042	0.9996	1.0113	1.0156	1.0025	0.9980
GROWCO	1.0078	1.0115	1.0109	1.0046	0.9985	1.0137	1.0197	1.0029	0.9971
Sum	1.0088	1.0114	1.0110	1.0051	0.9994	1.0140	1.0195	1.0031	0.9974
West Valley									
SJWCWS	1.0108	1.0134	1.0129	1.0062	0.9996	1.0166	1.0229	1.0036	0.9970
CALWCO	1.0081	1.0128	1.0121	1.0048	0.9980	1.0151	1.0219	1.0032	0.9967
CUPCTY	1.0089	1.0134	1.0126	1.0053	0.9982	1.0159	1.0229	1.0034	0.9967
MOFFET	1.0007	1.0003	1.0004	1.0004	1.0003	1.0005	1.0005	1.0001	1.0000
MTVCTY	1.0107	1.0096	1.0097	1.0059	1.0019	1.0129	1.0162	1.0029	0.9985
PALCTY	1.0067	1.0105	1.0099	1.0040	0.9984	1.0124	1.0180	1.0026	0.9973
PHLCWD	1.0062	1.0140	1.0128	1.0040	0.9959	1.0156	1.0240	1.0032	0.9959
SUNCTY	1.0079	1.0106	1.0101	1.0046	0.9993	1.0129	1.0180	1.0028	0.9976
SCLCTY	1.0069	1.0092	1.0088	1.0040	0.9994	1.0112	1.0157	1.0024	0.9979
Sum	1.0084	1.0109	1.0105	1.0049	0.9994	1.0134	1.0186	1.0029	0.9975
Total W-2	1.0083	1.0110	1.0105	1.0048	0.9993	1.0134	1.0187	1.0029	0.9975
South County									
GILROY	1.0079	1.0158	1.0146	1.0050	0.9960	1.0179	1.0271	1.0037	0.9955
MORGNH	1.0066	1.0128	1.0118	1.0041	0.9969	1.0145	1.0219	1.0030	0.9964
COYOTE	1.0040	1.0139	1.0124	1.0029	0.9944	1.0146	1.0238	1.0029	0.9955
SMARTN	1.0186	1.0636	1.0568	1.0134	0.9741	1.0671	1.1093	1.0134	0.9793
Total W-5	1.0094	1.0261	1.0236	1.0064	0.9907	1.0282	1.0449	1.0057	0.9918
Total M&I	1.0084	1.0127	1.0120	1.0050	0.9983	1.0151	1.0217	1.0032	0.9968

Table 2. Weather Multipliers for M&I Water Needs for the Year 2020

WSA	1976	1977	1978	1979	1980	1981	1982	1983	1984
East Valley									
SJNCTY	1.0041	1.0019	1.0042	1.0055	1.0012	1.0065	1.0005	1.0079	1.0083
SJWCES	1.0117	1.0055	1.0121	1.0158	1.0032	1.0182	1.0010	1.0227	1.0240
MILCTY	1.0092	1.0041	1.0097	1.0121	1.0032	1.0150	1.0015	1.0177	1.0183
SJSCTY	1.0142	1.0068	1.0146	1.0194	1.0035	1.0216	1.0008	1.0276	1.0295
Sum	1.0104	1.0049	1.0108	1.0141	1.0030	1.0164	1.0010	1.0203	1.0214
Central Valley									
SJWCSO	1.0163	1.0079	1.0168	1.0224	1.0040	1.0248	1.0008	1.0318	1.0340
SJWCCT	1.0094	1.0046	1.0097	1.0130	1.0023	1.0143	1.0005	1.0184	1.0197
GROWCO	1.0116	1.0054	1.0120	1.0156	1.0033	1.0182	1.0012	1.0224	1.0237
Sum	1.0117	1.0056	1.0121	1.0161	1.0029	1.0179	1.0007	1.0229	1.0244
West Valley									
SJWCWS	1.0138	1.0067	1.0142	1.0191	1.0033	1.0210	1.0006	1.0271	1.0290
CALWCO	1.0127	1.0059	1.0133	1.0171	1.0039	1.0204	1.0015	1.0247	1.0259
CUPCTY	1.0134	1.0063	1.0140	1.0181	1.0039	1.0212	1.0014	1.0260	1.0274
MOFFET	1.0004	1.0003	1.0004	1.0007	0.9999	1.0004	0.9998	1.0009	1.0010
MTVCTY	1.0105	1.0056	1.0105	1.0151	1.0012	1.0145	0.9991	1.0209	1.0231
PALCTY	1.0105	1.0049	1.0110	1.0141	1.0032	1.0167	1.0012	1.0203	1.0213
PHLCWD	1.0134	1.0058	1.0143	1.0174	1.0052	1.0226	1.0028	1.0256	1.0262
SUNCTY	1.0108	1.0052	1.0111	1.0147	1.0028	1.0165	1.0007	1.0210	1.0223
SCLCTY	1.0094	1.0045	1.0097	1.0128	1.0024	1.0144	1.0006	1.0183	1.0195
Sum	1.0112	1.0054	1.0115	1.0153	1.0028	1.0171	1.0007	1.0218	1.0233
Total W-2	1.0112	1.0054	1.0116	1.0153	1.0029	1.0172	1.0007	1.0218	1.0232
South County									
GILROY	1.0153	1.0067	1.0162	1.0201	1.0056	1.0254	1.0028	1.0294	1.0303
MORGNH	1.0124	1.0055	1.0131	1.0164	1.0044	1.0205	1.0021	1.0239	1.0247
COYOTE	1.0127	1.0052	1.0139	1.0161	1.0059	1.0227	1.0037	1.0242	1.0242
SMARTN	1.0585	1.0238	1.0636	1.0741	1.0273	1.1042	1.0168	1.1110	1.1110
Total W-5	1.0244	1.0102	1.0263	1.0313	1.0106	1.0425	1.0062	1.0466	1.0470
Total M&I	1.0127	1.0059	1.0133	1.0172	1.0038	1.0201	1.0014	1.0247	1.0260

Table 2. Weather Multipliers for M&I Water Needs for the Year 2020

WSA	1985	1986	1987	1988	1989	1990	1991	1992
East Valley								
SJNCTY	1.0107	1.0079	1.0107	1.0122	1.0077	1.0111	1.0048	1.0164
SJWCES	1.0304	1.0225	1.0304	1.0350	1.0219	1.0318	1.0138	1.0469
MILCTY	1.0243	1.0182	1.0245	1.0276	1.0176	1.0253	1.0109	1.0371
SJSCTY	1.0367	1.0270	1.0364	1.0424	1.0264	1.0384	1.0167	1.0567
Sum	1.0272	1.0202	1.0272	1.0313	1.0196	1.0285	1.0123	1.0419
Central Valley								
SJWCSO	1.0422	1.0311	1.0418	1.0488	1.0303	1.0442	1.0192	1.0652
SJWCCT	1.0244	1.0179	1.0241	1.0282	1.0175	1.0256	1.0111	1.0377
GROWCO	1.0303	1.0225	1.0302	1.0347	1.0218	1.0316	1.0137	1.0465
Sum	1.0304	1.0224	1.0301	1.0351	1.0218	1.0318	1.0138	1.0469
West Valley								
SJWCWS	1.0358	1.0263	1.0354	1.0415	1.0257	1.0375	1.0163	1.0554
CALWCO	1.0335	1.0249	1.0336	1.0383	1.0242	1.0349	1.0151	1.0514
CUPCTY	1.0351	1.0261	1.0351	1.0402	1.0253	1.0366	1.0159	1.0539
MOFFET	1.0009	1.0006	1.0008	1.0012	1.0007	1.0010	1.0005	1.0016
MTVCTY	1.0265	1.0191	1.0256	1.0314	1.0189	1.0280	1.0122	1.0416
PALCTY	1.0275	1.0205	1.0276	1.0315	1.0199	1.0287	1.0124	1.0422
PHLCWD	1.0358	1.0270	1.0364	1.0402	1.0260	1.0371	1.0160	1.0543
SUNCTY	1.0279	1.0206	1.0277	1.0322	1.0201	1.0292	1.0127	1.0431
SCLCTY	1.0244	1.0180	1.0242	1.0281	1.0175	1.0255	1.0111	1.0376
Sum	1.0290	1.0214	1.0288	1.0335	1.0209	1.0304	1.0132	1.0448
Total W-2	1.0291	1.0214	1.0289	1.0336	1.0209	1.0304	1.0132	1.0449
South County								
GILROY	1.0406	1.0305	1.0412	1.0459	1.0295	1.0422	1.0182	1.0619
MORGNH	1.0329	1.0247	1.0334	1.0373	1.0239	1.0343	1.0148	1.0503
COYOTE	1.0347	1.0265	1.0358	1.0385	1.0253	1.0358	1.0154	1.0523
SMARTN	1.1591	1.1215	1.1643	1.1767	1.1162	1.1643	1.0706	1.2399
Total W-5	1.0659	1.0501	1.0677	1.0737	1.0481	1.0682	1.0294	1.0998
Total M&I	1.0333	1.0248	1.0333	1.0382	1.0240	1.0348	1.0151	1.0512

Table 3. Year 2020 M&I Water Needs for Historical Weather Conditions, in Acre-feet

WSA	1967	1968	1969	1970	1971	1972	1973	1974	1975
East Valley									
SJNCTY	12630	12648	12645	12616	12589	12657	12685	12610	12584
SJWCES	38205	38335	38313	38078	37851	38423	38644	38010	37791
MILCTY	17500	17575	17563	17466	17375	17599	17692	17451	17367
SJSCTY	14947	14993	14985	14881	14778	15040	15137	14844	14743
Sum	83281	83552	83507	83042	82594	83719	84158	82914	82484
Central Valley y									
SJWCSO	36172	36296	36274	35986	35703	36426	36695	35881	35601
SJWCCT	70839	70975	70950	70625	70305	71125	71428	70503	70186
GROWCO	16158	16218	16208	16107	16010	16254	16349	16080	15987
Sum	123169	123489	123432	122718	122018	123805	124472	122465	121775
West Valley									
SJWCWS	42038	42150	42129	41849	41573	42282	42543	41742	41467
CALWCO	18956	19045	19031	18895	18766	19088	19216	18864	18742
CUPCTY	4050	4068	4065	4036	4007	4078	4106	4028	4001
MOFFET	1258	1258	1258	1258	1258	1258	1258	1257	1257
MTVCTY	22875	22850	22852	22767	22676	22926	23001	22700	22599
PALCTY	26283	26382	26366	26213	26066	26431	26577	26176	26037
PHLCWD	2185	2202	2199	2180	2163	2205	2224	2179	2163
SUNCTY	47126	47250	47228	46972	46722	47357	47597	46887	46642
SCLCTY	47901	48010	47991	47764	47543	48106	48318	47688	47471
Sum	212672	213214	213118	211933	210774	213731	214839	211521	210379
Total W-2	419122	420255	420057	417692	415386	421256	423470	416900	414638
South County									
GILROY	18788	18935	18912	18733	18565	18973	19145	18709	18556
MORGNH	11946	12020	12008	11917	11831	12040	12128	11904	11825
COYOTE	10888	10994	10978	10875	10782	11002	11102	10875	10795
SMARTN	13150	13732	13643	13084	12576	13777	14322	13084	12643
Total W-5	54772	55680	55541	54608	53755	55792	56696	54572	53819
Total M&I	473894	475935	475598	472300	469141	477048	480165	471472	468457

Table 3. Year 2020 M&I Water Needs for Historical Weather Conditions, in Acre-feet

WSA	1976	1977	1978	1979	1980	1981	1982	1983	1984
East Valley									
SJNCTY	12648	12621	12650	12666	12612	12678	12603	12696	12701
SJWCES	38339	38106	38356	38497	38019	38587	37935	38757	38807
MILCTY	17571	17483	17580	17623	17467	17673	17437	17719	17730
SJSCTY	14998	14890	15005	15076	14841	15109	14801	15197	15225
Sum	83556	83099	83591	83862	82939	84047	82776	84369	84463
Central Valley									
SJWCSO	36311	36010	36328	36528	35871	36615	35759	36865	36943
SJWCCT	70993	70651	71012	71242	70489	71337	70362	71625	71715
GROWCO	16219	16120	16226	16284	16087	16325	16052	16393	16413
Sum	123522	122782	123567	124054	122446	124277	122173	124884	125070
West Valley									
SJWCWS	42167	41871	42183	42384	41727	42462	41616	42716	42795
CALWCO	19043	18914	19055	19126	18878	19187	18833	19268	19291
CUPCTY	4068	4040	4071	4087	4030	4100	4020	4119	4125
MOFFET	1258	1258	1258	1258	1257	1258	1257	1258	1258
MTVCTY	22872	22759	22871	22975	22661	22961	22614	23106	23156
PALCTY	26381	26234	26393	26475	26190	26543	26139	26637	26664
PHLCWD	2201	2184	2203	2209	2183	2221	2178	2227	2228
SUNCTY	47259	46997	47276	47444	46885	47529	46789	47736	47799
SCLCTY	48018	47786	48033	48183	47686	48258	47600	48442	48499
Sum	213266	212042	213341	214141	211497	214518	211046	215511	215815
Total W-2	420345	417923	420498	422058	416882	422842	415994	424764	425348
South County									
GILROY	18924	18766	18942	19014	18744	19113	18691	19187	19204
MORGNH	12015	11933	12024	12062	11920	12111	11893	12151	12161
COYOTE	10982	10900	10994	11019	10908	11090	10884	11106	11106
SMARTN	13665	13218	13732	13867	13263	14255	13128	14344	14344
Total W-5	55586	54816	55691	55962	54835	56569	54596	56788	56815
Total M&I	475931	472739	476190	478020	471717	479411	470590	481551	482162

Table 3. Year 2020 M&I Water Needs for Historical Weather Conditions, in Acre-feet

WSA	1985	1986	1987	1988	1989	1990	1991	1992
East Valley								
SJNCTY	12731	12697	12732	12751	12694	12737	12658	12803
SJWCES	39050	38751	39047	39223	38728	39102	38420	39673
MILCTY	17834	17728	17839	17891	17718	17851	17602	18057
SJSCTY	15331	15189	15327	15416	15179	15357	15036	15627
Sum	84947	84365	84944	85282	84318	85048	83714	86161
Central Valley								
SJWCSO	37236	36839	37222	37473	36812	37307	36415	38058
SJWCCT	72045	71592	72028	72317	71562	72127	71111	72982
GROWCO	16518	16393	16518	16590	16383	16540	16253	16779
Sum	125799	124824	125768	126379	124758	125974	123778	127820
West Valley								
SJWCWS	43079	42685	43063	43316	42660	43151	42269	43894
CALWCO	19433	19273	19436	19524	19259	19461	19088	19770
CUPCTY	4155	4119	4155	4176	4116	4162	4078	4231
MOFFET	1258	1258	1258	1259	1258	1258	1258	1259
MTVCTY	23233	23065	23212	23345	23060	23267	22910	23574
PALCTY	26825	26641	26827	26929	26626	26856	26432	27209
PHLCWD	2249	2230	2251	2259	2228	2252	2206	2290
SUNCTY	48062	47720	48053	48264	47696	48123	47349	48772
SCLCTY	48731	48427	48723	48911	48406	48785	48099	49361
Sum	217026	215419	216979	217981	215308	217315	213689	220360
Total W-2	427772	424608	427691	429642	424384	428336	421182	434340
South County								
GILROY	19397	19209	19408	19496	19189	19427	18980	19794
MORGNH	12259	12161	12264	12311	12151	12274	12043	12464
COYOTE	11220	11131	11232	11261	11118	11232	11010	11410
SMARTN	14965	14479	15032	15191	14411	15032	13822	16007
Total W-5	57840	56980	57935	58259	56869	57965	55855	59676
Total M&I	485612	481588	485626	487902	481254	486301	477037	494016